Name________________________________________

Physics 111 Quiz #5, November 7, 2014

*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 were conducting a photoelectric effect experiment with blue light ($\lambda = 470nm$) with intensity $S$ and that this light were incident on a cesium surface ($\phi = 2.1eV$). What potential difference would be needed to stop the electrons from striking the collector?

The stopping potential is given by

$$eV_{stop} = \frac{hc}{\lambda} - \phi = \left\{\left[\frac{6.6\times10^{-34}\,Js\times3\times10^{8}\,\frac{m}{s}}{470\times10^{-9}\,m}\right]\times\frac{1eV}{1.6\times10^{-19}\,J}\right\} - 2.1eV$$

$$eV_{stop} = 2.63eV - 2.1eV = 0.53eV$$

$$\therefore V_{stop} = 0.53V$$

2. If the intensity of the blue light that was used were reduced to $\frac{S}{2}$, which of the following would happen?
   a. The number of photoelectrons would increase by a factor of $2$, while the speed of the ejected photoelectrons would decrease by a factor of $\sqrt{2}$.
   b. The number of photoelectrons would increase by a factor of $2$, while the speed of the ejected photoelectrons would be increased by a factor of $\sqrt{2}$.
   c. The number of photoelectrons would decrease by a factor of $2$, while the speed of the ejected photoelectrons would be increase by a factor $\sqrt{2}$.
   d. The number of photoelectrons would decrease by a factor of $2$, while the speed of the ejected photoelectrons would decrease by a factor of $\sqrt{2}$.
   e. The number of photoelectrons would increase by a factor of $2$ and their speeds would independent of the intensity of the light.
   f. The number of photoelectrons would decrease by a factor of $2$ and their speeds would be independent of the intensity of the light.
   g. Neither the number of photoelectrons ejected nor the speed of the ejected photoelectrons would change.

3. Suppose that an unstable particle at rest initially breaks up into two fragments of *unequal mass*. The mass of the lighter fragment is $2.5\times10^{-28}\,kg$ and the mass of the heavier fragment is $1.7\times10^{-27}\,kg$. If the lighter fragment has a speed of $0.893c$ after the breakup, what is the speed of the heavier fragment?

Since the system starts at rest, the initial momentum is zero. Momentum is conserved, so we have $\vec{p}_i = \vec{p}_f \rightarrow 0 = \gamma_L m_L v_L - \gamma_H m_H v_H \rightarrow \gamma_H v_H = \gamma_L \frac{m_L}{m_H} v_L$. Calling the factor on the right hand side of the equation, $A$, we have $\gamma_H v_H = \gamma_L \frac{m_L}{m_H} v_L = A \rightarrow \frac{v_H}{\sqrt{1-\frac{v_H^2}{c^2}}} = A^2 \rightarrow v_H = \sqrt{\frac{A^2}{1+\frac{A^2}{c^2}}}$.

Evaluating $A$ we have, $A = \gamma_L \frac{m_L}{m_H} v_L = \left[\frac{1}{\sqrt{1-\left(\frac{0.893c}{c}\right)^2}}\right]\left(\frac{2.5\times10^{-28}\,kg}{1.7\times10^{-27}\,kg}\right)\times 0.893c = 0.292c$.

Using this value, we can determine the speed of the heavier fragment. We have

$$v_H = \sqrt{\frac{A^2}{1+\frac{A^2}{c^2}}} = \sqrt{\frac{(0.292c)^2}{1+\left(\frac{0.292c}{c}\right)^2}} = 0.280c.$$

# 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

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

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

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

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

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

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

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

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

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

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

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

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

$$N_A = 6.02\times10^{23}$$

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

## 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

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

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

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

## Light as a Wave

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

$$S(t) = \frac{energy}{time\times area} = c\varepsilon_o E^2(t) = c\frac{B^2(t)}{\mu_0}$$

$$I = S_{avg} = \tfrac{1}{2}c\varepsilon_o E_{\max}^2 = c\frac{B_{\max}^2}{2\mu_0}$$

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

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

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

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

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

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

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

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

$$d\sin\theta = m\lambda \text{ or } (m+\tfrac{1}{2})\lambda$$

$$a\sin\phi = m'\lambda$$

## 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

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

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

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

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

$$PE_{gravity} = mgy$$

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