Physics 30 – Lesson 29
The Photoelectric Effect

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1)

a) $E_{photon} = \frac{hc}{\lambda}$

$E_{photon} = \frac{6.63\times10^{-34}\,J\cdot s(3.00\times10^{8}\,{}^{m}/_{s})}{500\times10^{-9}\,m}$

$\boxed{E_{photon} = 3.98\times10^{-19}\,J}$

b)

$n_{photons} = \frac{E_{total}}{E_{photon}}$

$n_{photons} = \frac{100J}{3.98\times10^{-19}\,J}$

$\boxed{n_{photons} = 2.51\times10^{20}\,photons}$

c) For every photon an electron is emitted

$n_{e^-} = n_{photons}\times area$

$n_{e^-} = \frac{2.51\times10^{20}\,photons}{m^2}\times(0.050m)^2$

$\boxed{n_{e^-} = 6.28\times10^{17}\,electrons}$

$I = \frac{q}{t}$

$I = \frac{n_{e^-}\times q_{e^-}}{t}$

$I = \frac{6.28\times10^{17}e^-\times1.6\times10^{-19}\,{}^{C}/_{e^-}}{1s}$

$\boxed{I = 0.101A}$

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2)

A. The photocurrent will increase with increased intensity
B. The photo current will not be affected by a change in frequency
C. The kinetic energy of the photoelectrons will not change with intensity
D. As frequency increases, the kinetic energy of the photoelectrons increases.

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3)

$W = hf_o$

$f_o = \frac{W}{h}$

$f_o = \frac{2.0eV}{4.14\times10^{-15}eV\cdot s}$

$\boxed{f_o = 4.8\times10^{14}\,Hz}$

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4)

$W = hf_o = \frac{hc}{\lambda_o}$

$\lambda_o = \frac{hc}{W}$

$\lambda_o = \frac{4.14\times10^{-15}eV\cdot s(3.0\times10^{8}\,{}^{m}/_{s})}{4.6eV}$

$\boxed{\lambda_o = 2.7\times10^{-7}\,m}$

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5)

$E_k = E_{photon} - W$

$E_k = \frac{hc}{\lambda} - hf_o$

/6 $E_k = h\left(\frac{c}{\lambda} - f_o\right)$

$170nm \rightarrow E_k = h\left(\frac{c}{\lambda} - f_o\right)$

$E_k = 6.63\times10^{-34} J\cdot s\left(\frac{3.0\times10^{8}\ {}^{m}\!/\!_{s}}{170\times10^{-9} m} - 1300\times10^{12} Hz\right)$

$\boxed{E_k = 3.08\times10^{-19} J}$

$300nm \rightarrow E_k = h\left(\frac{c}{\lambda} - f_o\right)$

$E_k = 6.63\times10^{-34} J\cdot s\left(\frac{3.0\times10^{8}\ {}^{m}\!/\!_{s}}{3.0\times10^{-7} m} - 1300\times10^{12} Hz\right)$

$E_k = -1.99\times10^{-19} J$

$\boxed{\text{negative } E_k \text{ means no electron is emitted using 300nm}}$

6)

$E = W + E_k$

$\frac{hc}{\lambda} = W + \frac{1}{2}mv^2$

/5 $\lambda = \frac{hc}{W + \frac{1}{2}mv^2}$

$\lambda = \frac{6.63\times10^{-34} J\cdot s(3.0\times10^{8}\ {}^{m}\!/\!_{s})}{2.55_{eV}\times1.60\times10^{-19}\ {}^{J}\!/\!_{eV} + \frac{1}{2}(9.11\times10^{-31} kg)(4.20\times10^{5}\ {}^{m}\!/\!_{s})^2}$

$\boxed{\lambda = 407nm}$

7)

$E_k = E - W$

$qV = E - W$

/3 $V = \frac{hf - W}{q}$

$V = \frac{4.14\times10^{-15} eV\cdot s(7.52\times10^{14} Hz) - 2.2eV}{1e}$

$\boxed{V = 0.913V}$

or

$V = \frac{6.63\times10^{-34} J\cdot s(7.52\times10^{14} Hz) - 2.2eV(1.60\times10^{-19}\ {}^{J}\!/\!_{eV})}{1.60\times10^{-19} C}$

$\boxed{V = 0.916V}$