Physics 267 Problem #11 solutions

(1.)

$E = nc/\lambda$

$I = \frac{P}{A}$

$t = 1\,s$

P: power

Energy = Power × time

N: number of photons

$NE = Pt$

$$N = \frac{Pt}{E} = \frac{AIt}{E} = \frac{AIt\lambda}{hc}$$

$$N_{\lambda=488} = \frac{(1cm)^2\left(1\,W/cm^2\right)(1s)\left(488\times10^{-9}\,m\right)}{\left(6.626\times10^{-34}\,J\cdot s\right)\left(3.0\times10^{9}\,m/s\right)}$$

$N_{\lambda=488} = 2.5\times10^{18}$

$N_{\lambda=633} = 3.2\times10^{18}$

(2.) $E_{\lambda=488} = \frac{hc}{\lambda} = \frac{\left(6.626\times10^{-34}\,J\cdot s\right)\left(3.0\times10^{8}\,m/s\right)}{488\times10^{-9}\,m} = 4.1\times10^{-19}\,J$

$= \frac{1240\ nm\cdot eV}{488\ nm} = 2.5\ eV$

$E_{\lambda=633} = 3.1\times10^{-19}\,J$

$= 2.0\ eV$

(3.)

$p_\lambda = E/c$ ← momentum of each photon

$F = \frac{dp}{dt}$

$P_{rad} = \frac{F}{A}$ pressure

$F = p_\lambda * (\text{photons per second})$

photons per second is

$\frac{N}{t} = R = \frac{IA}{E}$ ↗ from (1)

$P_{rad} = \frac{F}{A} = \frac{p_\lambda R}{A} = \frac{(E/c)\left(\frac{IA}{E}\right)}{A} = I/c$

(4.)

$\phi = \frac{hc}{\lambda}$ where $\lambda = 633$ nm

$\phi = \frac{hc}{633\text{ nm}}$

$K = \frac{hc}{488\text{ nm}} - \frac{hc}{633\text{nm}} = 1240\text{ nm}\cdot\text{eV}\left(\frac{1}{488\text{nm}} - \frac{1}{638\text{ nm}}\right)$

$= 0.58$ eV.