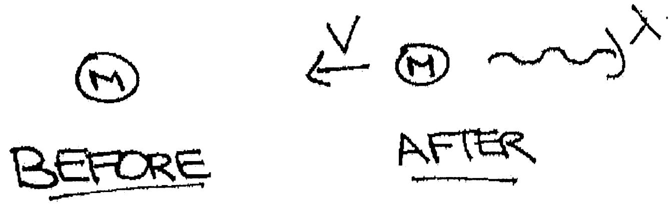
PHYS 262 : HW # 6   38.52, 38.53, 38.54, 38.59, 38.62

38.52



BEFORE: $P_{TOTAL} = 0$ AFTER: $P_{TOTAL} = P_{PHOTON} - P_{ATOM} = \frac{E}{c} - MV$

$$\Rightarrow 0 = \frac{E}{c} - MV \Rightarrow V = \frac{E}{MC} = \frac{\left(\frac{hc}{\lambda}\right)}{MC} \Rightarrow \boxed{V = \frac{h}{M\lambda}}$$

a. K OF ATOM?

$$K = \frac{1}{2}MV^2 = \frac{1}{2}M\left(\frac{h}{M\lambda}\right)^2 \Rightarrow \boxed{K = \frac{h^2}{2M\lambda^2}}$$

b. K/E = ?

$$\frac{K}{E} = \frac{\frac{h^2}{2M\lambda^2}}{\frac{hc}{\lambda}} = \frac{h^2}{2M\lambda^2} \cdot \frac{\lambda}{hc} \Rightarrow \boxed{\frac{K}{E} = \frac{h}{2M\lambda c}}$$

IMPORTANT FOR SMALL MASSES AND WAVELENGTHS

c. $M = 1.67 \times 10^{-27}$ kg, $E = 10.2$ eV, K/E = ?

$$\frac{K}{E} = \frac{h}{2M\lambda c} = \frac{hc}{\lambda}\left(\frac{1}{2MC^2}\right) = \frac{E}{2MC^2}$$

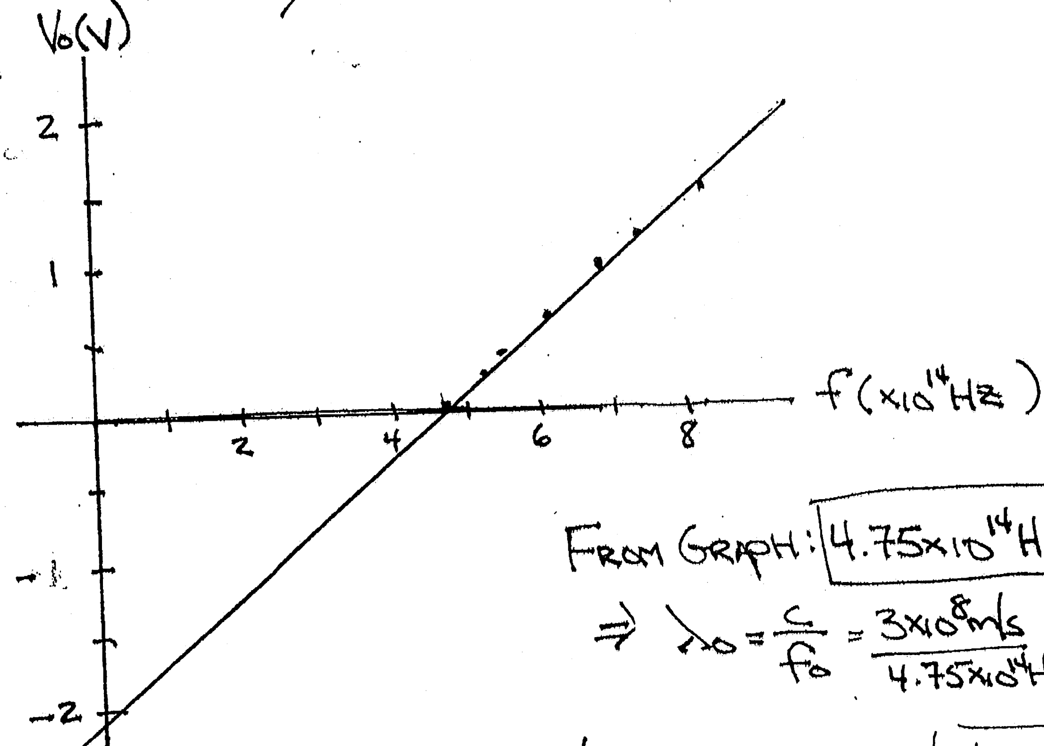
$$MC^2 = (1.67 \times 10^{-27} kg)(3 \times 10^8 m/s)^2 = 1.5 \times 10^{-10} J \times \frac{eV}{1.6 \times 10^{-19} J} = 9.39 \times 10^8 eV$$

$$\Rightarrow \frac{K}{E} = \frac{10.2 eV}{2(9.39 \times 10^8 eV)} \Rightarrow \boxed{\frac{K}{E} = 5.43 \times 10^{-9}}$$ ← VERY NEGLIGIBLE

38.53 PLOT V_0 VS. f → USE $f = \frac{c}{\lambda}$ TO FIND FREQUENCY.

λ (nm)	f (Hz)	V_0 (V)
366	8.2×10^{14}	1.48
405	7.4×10^{14}	1.15
436	6.9×10^{14}	.93
492	6.1×10^{14}	.62
546	5.5×10^{14}	.36
579	5.2×10^{14}	.24

WE KNOW $eV_0 = hf - \phi$ ⇒ $V_0 = \frac{h}{e}f - \phi/e$ ⇒ STRAIGHT LINE WITH X INTERCEPT f_0, Y INTERCEPT $-\phi/e$, AND SLOPE h/e.



FROM GRAPH: $\boxed{4.75\times10^{14}\text{ Hz} = f_0}$

$$\Rightarrow \lambda_0 = \frac{c}{f_0} = \frac{3\times10^8\text{ m/s}}{4.75\times10^{14}\text{ Hz}} \Rightarrow \boxed{6.3\times10^{-7}\text{ m} = 630\text{ nm}}$$

$$-\frac{\phi}{e} = -2.1\text{ V} \Rightarrow \boxed{\phi = 2.1\text{ eV}}$$

$$\frac{h}{e} = \frac{0-(-2.1\text{ V})}{4.75\times10^{14}\text{ Hz} - 0} = 4.4\times10^{-15}\text{ V}\cdot\text{s}$$

$$\Rightarrow \boxed{h = 4.4\times10^{-15}\text{ eV}\cdot\text{s}}$$

38.54 $f = 5\times10^{14}$ Hz, $P = 200$ WATT, 10% CONVERTED to PHOTONS

10% (200 WATT) = 20 WATT = 20 J/s. TOTAL ENERGY = total # x $\text{ENERGY}_{\text{photons}}$

$\Rightarrow 20\text{ J/s} = Nhf \Rightarrow N = \dfrac{20\text{ J/s}}{(6.63\times10^{-34}\text{ J}\cdot\text{s})(5\times10^{14}\text{ Hz})} \Rightarrow \boxed{N = 6\times10^{19}/\text{s}}$

b AT WHAT DISTANCE IS $\frac{N}{A} = 1\times10^{11}/\text{cm}^2\cdot\text{s}$. EMITTED IN ALL DIRECTION $\Rightarrow A = 4\pi r^2$

$\Rightarrow \dfrac{N}{4\pi r^2} = 1\times10^{11}/\text{cm}^2\text{s} \Rightarrow r^2 = \dfrac{N}{4\pi(1\times10^{11}/\text{cm}^2\cdot\text{s})} = \dfrac{6\times10^{19}/\text{s}}{4\pi(1\times10^{11}/\text{cm}^2\cdot\text{s})} \Rightarrow \boxed{r = 6900\text{ cm} = 69\text{ m}}$

38.59 PROTON & MUON : $M = 207 M_e$

a $\mu = \dfrac{M_p M_m}{M_p + M_m} = \dfrac{M_p(207 M_e)}{M_p + 207 M_e}$. $M_p = 1.67\times10^{-27}$ Kg, $M_e = 9.11\times10^{-31}$ Kg

$\Rightarrow \boxed{\mu = 1.69\times10^{-28}\text{ Kg} = 185.5 M_e}$

b $E_n = ?$ WHEN $\mu = M_e$, $E_n = \dfrac{-13.6\text{ eV}}{n^2}$.

$E_n \propto \mu \Rightarrow E_n = \dfrac{185.5(-13.6\text{ eV})}{n^2} \Rightarrow \boxed{E_n = \dfrac{-2523\text{ eV}}{n^2}} \Rightarrow \boxed{E_1 = -2523\text{ eV}}$

c WHAT WAVELENGTH IS EMITTED FOR $n=2$ to $n=1$?

$E_2 = \dfrac{-2523\text{ eV}}{4} = -613\text{ eV} \Rightarrow \Delta E = -2523\text{ eV} - (-613\text{ eV}) = -1910\text{ eV}$

$\Rightarrow E = 1910\text{ eV} = \dfrac{hc}{\lambda} \Rightarrow 1910\text{ eV} = \dfrac{(4.14\times10^{-15}\text{ eVs})(3\times10^8\text{ m/s})}{\lambda}$

$\Rightarrow \boxed{\lambda = 6.5\times10^{-10}\text{ m} = .65\text{ nm}}$

38.62 $M = 20\,kg,\ T = 2h = 7200\,s,\ r = 8060\,km = 8.06\times10^6\,m$

a $n = ?$ if $L = n\hbar$. $L = mvr$.

CIRCULAR ORBIT $\Rightarrow 2\pi r = vT \Rightarrow v = \frac{2\pi r}{T}$

$$\Rightarrow M\left(\frac{2\pi r}{T}\right)r = n\hbar \Rightarrow n = \frac{M2\pi r^2}{T\hbar} = \frac{(20\,kg)(2\pi)(8.06\times10^6\,m)^2}{7200\,s\,(1\times10^{-34}\,J\cdot s)}$$

$$\Rightarrow \boxed{n = 1.13\times10^{46}}$$

b $$F = \frac{GM_EM}{r^2} = \frac{Mv^2}{r} \Rightarrow GM_EM = Mv^2r = Mvr\,v = n\hbar v$$

$$\Rightarrow v = \frac{GM_EM}{n\hbar}. \quad Mvr = n\hbar \Rightarrow r = \frac{n\hbar}{M\left(\frac{GM_EM}{n\hbar}\right)} = \frac{\hbar^2}{GM_EM^2}n^2$$

$$\Rightarrow r = \frac{(1\times10^{-34}\,J\cdot s)^2\, n^2}{(6.67\times10^{-11}\frac{Nm^2}{kg^2})(5.97\times10^{24}\,kg)(20\,kg)^2} = \boxed{6.28\times10^{-86}\,m\,n^2 = r}$$

$$\Delta r = 6.28\times10^{-86}\,m^2\left((n+1)^2 - n^2\right) = 6.28\times10^{-86}\,m^2\left(n^2+2n+1-n^2\right)$$

$$= 6.28\times10^{-86}\,m^2(2n+1) \approx 6.28\times10^{-86}\,m^2\,(2n) \quad (\text{for } n = 1.13\times10^{46})$$

$$\Rightarrow \boxed{\Delta r = 1.42\times10^{-39}\,m}$$ NOT NOTICEABLE

c ORBITS DO CORRESPOND. FOR $n = 1.13\times10^{46}$, $(6.28\times10^{-86}\,m)(1.13\times10^{46})^2 = 8.02\times10^6 = 8\times10^6\,m$

BUT CLASSICAL METHODS SUFFICE.