Homework #11

12.1 Photoelectric effect

$$E = hf - \varphi \geq 0 \qquad hf_{co} = \varphi$$

$$f_{co} = \varphi/h = \frac{6.33\,eV}{4.14\cdot10^{-15}\,eV\cdot s} = 1.53\cdot10^{15}\,Hz$$

$$\lambda_{co} = c/f_{co} = 196\ nm$$

Such solar cell would absorb the majority of the sun spectrum

12.3

Photon: $hf = \frac{h\cdot c}{\lambda} = E \qquad \lambda = \frac{hc}{E} = \frac{1.24\cdot10^{-6}\,eV\cdot m}{1eV}$

$= 1.24\,\mu m$

Electron: $E^2 = p^2c^2 + m^2c^4 \qquad K = E - mc^2$

$K \ll mc^2 \quad (1eV \ll 0.5\,MeV)$ – slow (non-relativistic) $\bar{e}$

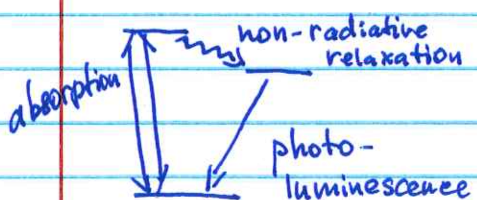
$K \approx P^2/2m \qquad p = \sqrt{2mK}$

$$\lambda = \frac{h}{p} = \frac{h}{\sqrt{2mK}} = \frac{hc}{\sqrt{2(mc^2)\cdot K}} = \frac{1.24\cdot10^{-6}\,eV\cdot m}{\sqrt{2\cdot5\cdot10^{5}\,eV\cdot 1eV}}$$

$$\lambda = 1.23\cdot10^{-9}\,m$$

12.12

When light is absorbed, part of photon's energy can be used for non-radiative processes, and the emitted photon has lower energy



$\hbar\omega_{emitted} < \hbar\omega_{abs}$

$\lambda_{emitted} > \lambda_{absorbed}$

A1

Assuming $m = 80 kg$ and $v = 5\ ^{km}/_{hr}$ ⇒

$$p = mv = 111\ kg \cdot {}^{m}/_{s}$$

$$\lambda = {}^{h}/_{p} = \frac{2\pi \cdot 10^{-34}\ J\cdot s}{111\ kg \cdot {}^{m}/_{s}} \simeq 5.6 \cdot 10^{-36}\ m$$

To experience diffraction the wavelength of an incoming "wave" should be comparable with the distances b/w the "slits"

$$\lambda \sim 10^{-10} m \quad \Rightarrow \quad p \simeq {}^{h}/_{\lambda} = 6.3 \cdot 10^{-24}\ kg \cdot {}^{m}/_{s}$$

$$v \simeq 8 \cdot 10^{-26}\ m/s$$

Much smaller than thermal velocity of atoms/molecules, so all quantum effects are smeared.

A2

$$|\psi\rangle = \frac{4}{5}|h\rangle + \frac{3}{5}|t\rangle$$

$$P_{head} = \left(\frac{4}{5}\right)^2 = 0.64$$

$$P_{tail} = (3/5)^2 = 0.36$$

Equal probability $\quad |\psi_1\rangle = \frac{1}{\sqrt{2}}|h\rangle + e^{i\varphi}\frac{1}{\sqrt{2}}|t\rangle$

where φ is any real argument $[0, 2\pi]$

13.6

$$hf = E_3 - E_1 = -\frac{R_y}{3^2} + \frac{R_y}{1} = \frac{8}{9} R_y = 12.1 eV$$

$$\overset{\shortparallel}{\frac{hc}{\lambda}} \quad \Rightarrow \quad \lambda = \frac{hc}{E_3 - E_1} = \frac{1.24 \cdot 10^{-6} eV \cdot m}{12.1 eV} = 102\ nm$$