Physics 116
Winter 2007
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Answers to some additional Problems from Ch. 30, 31.

$\boxed{30\text{-}7}$ (a) Since $f_{peak} = \text{constant} \times T$ the one with the highest T emits radiation with the highest f_{peak} -

(b) $\frac{f_{hal}}{f_{std}} = \frac{T_{hal}}{T_{std}} = \frac{3400\,K}{2900\,K} = 1.17$

(c) $f_{peak} = 5.88 \times 10^{10}\, s^{-1} K^{-1}\, T$ [Eqn. 30-1 of text]

so for 3400K $\rightarrow f_{peak} = 2 \times 10^{14}$ Hz (halogen)

for 2900K $\rightarrow f_{peak} = 1.7 \times 10^{14}$ Hz (regular)

The halogen lamp has f_{peak} closer to 5.5×10^{14} Hz (yellow)

—o—

$\boxed{30\text{-}11}$ $\frac{n\, hf}{1\,sec} \times 1\,sec$ = Power emitted.

$$n = \frac{\text{Power emitted} \times 1\,\text{second}}{hf} = \frac{270 \times \cancel{10^{3}}\, \frac{Joules}{Sec} \times 1\,sec}{6.63 \times 10^{-34}\, Js \times 950 \times \cancel{10^{3}}\, \frac{1}{s}} =$$

$$= 4.29 \times 10^{32} \text{ photons}$$

—o—

$\boxed{30\text{-}19}$ Dissociation energy of $H_2 = \frac{104\, kcal \times 4186\, Joules/kcal}{Mole \times 6.022\, \frac{molecules}{mole} \times 10^{23}} =$

$$E = 7.229 \times 10^{-19}\, \frac{Joules}{molecule} = hf = \frac{hc}{\lambda}$$

$$f = \frac{7.229 \times 10^{-19}\, \frac{Joules}{molecule} \times 1\,molecule}{6.63 \times 10^{-34}\, Joules\, second} = 1.09 \times 10^{15}\, Hz$$

$$\lambda = \frac{c}{f} = 2.75 \times 10^{-7}\, m$$

(b) ultraviolet

—o—

$\boxed{30\text{-}25}$

$W_{Zn} = 4.33\,eV$, $W_{Cd} = 4.22\,eV$

(a) The one with the smallest work function will need the smallest energy to remove an electron (Cd in this case) - So for same radiation, electrons from Cd will leave with the highest kinetic energy -

(b) $\lambda = 275\ nm$, $f = \frac{3\times10^8\ m/s}{275\times10^{-9}m} = 1.091\times10^{15}\ \frac{1}{s}$

Energy of photon $= hf = 6.63\times10^{-34}J\ sec \times 1.091\times10^{15}\ \frac{1}{s} = 7.23\times10^{-19}\ J$

$\equiv 4.52\ eV$.

$KE_{cd} = 4.52eV - 4.22\ eV = 0.30eV$

$KE_{Zn} = 4.52eV - 4.33\ eV = 0.19eV$

$\boxed{30\text{-}35}$ Photon momentum $p = \frac{E}{c} = \frac{h}{\lambda}$ - The recoil momentum of the hydrogen atom should be equal in magnitude and in the opposit direction. So $\frac{h}{\lambda} = m_H v \Rightarrow v = \frac{h}{\lambda m_H} = \frac{6.63\times10^{-34}\ Joule\ s}{122\times10^{-9}m \times 1.67\times10^{-27}kg}$

$= 3.25\ m/s$ (mass of H atom $\approx m_{proton}$ in back cover of text).

$\boxed{30\text{-}39}$ $P = 5.00\ mW$, $\lambda = 632.8\ nm$

(a) $\frac{n\,hf}{1sec} = Power \Rightarrow n = \frac{(Power)\times 1sec \times \lambda}{h\times c}$

$= \frac{5\times10^{-3}W \times 1s \times 632.8\times10^{-9}m}{6.63\times10^{-34}Js \times 3\times10^8 m/s} = 1.59\times10^{16}\ \frac{photons}{second}$.

(b) $p_{photon} = \frac{h}{\lambda} \Rightarrow \vec{P}_{in}$ Since photons are absorbed the change in momentum is $0 - p_{photon} = \Delta p = -\frac{h}{\lambda} = -\frac{6.63\times10^{-34}Js}{632.8\times10^{-9}m}$

$= -1.05\times10^{-27}\ kg\frac{m}{s}$

(c) $F = \frac{\Delta p}{\Delta t} \times$ number of photons $= 1.05\times10^{-27}\frac{kg\,m}{s} \times 1.59\times10^{16}\ \frac{photons}{second} =$

$= 1.67\times10^{-11}$ Newtons $\equiv 0.167$ pico Newtons

$\boxed{30\text{-}57}$ $m_{proton} = 1.67\times10^{-27}kg$ $m_e = 9.11\times10^{-31}\ kg$.

(a) Kinetic Energy $= \frac{1}{2}mv^2 = \frac{p^2}{2m} = \frac{h^2}{2m\lambda^2}$

so if the deBroglie's wavelengths are the same for the two particles the one with the smaller mass has more kinetic energy.

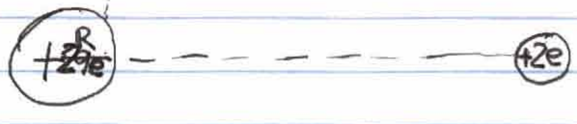
(b) $\frac{(KE)_{electron}}{(KE)_{proton}} = \frac{m_p}{m_e} = \frac{1.67\times10^{-27}kg}{9.11\times10^{-31}kg} = 1833$

30-69 $\Delta p_y \Delta y = \frac{h}{2\pi}$ and $\frac{\Delta p_x}{p_x} = 0.01$

So $\Delta y = \frac{h}{2\pi\, 0.01\, p_y} = \frac{6.63\times10^{-34}\,Js}{2\times\pi\times0.01\times1.7\times10^{-25}\,\frac{kg\,m}{s}} = 6.2\times10^{-8}\,m$

$\equiv 62\,nm$

31-3



Potential at the surface of the nucleus (sphere of charge) is

$V = \frac{kQ}{R}$ with $Q = +29\times1.6\times10^{-19}\,C$

The work needed to bring a charge from ∞ to R is

$W = Vq$, with $q = 2e = 2\times1.6\times10^{-19}\,C$

So $W = \frac{9\times10^9\times29\times1.6\times10^{-19}\times2\times1.6\times10^{-19}}{\frac{1}{2}\times4.8\times10^{-15}} = 5.57\times10^{-12}\,J$

31-7 Lyman series is the one with $n=1$, in the U.V.

$\frac{1}{\lambda} = R\left[\frac{1}{1^2} - \frac{1}{n^2}\right]$

The longest wavelengths are the ones for the smallest "n"s

$\frac{1}{\lambda_1} = R\left[\frac{1}{1^2} - \frac{1}{2^2}\right] = 1.097\times10^7\,m^{-1}\left[\frac{3}{4}\right] = 8.228\times10^6\,m^{-1}$;

$\lambda_1 = 1.215\times10^{-7}\,m \Rightarrow 121.5\,nm$.

$\frac{1}{\lambda_2} = R\left[\frac{1}{1^2} - \frac{1}{3^2}\right] = \frac{1.097\times10^7\times8}{9} \Rightarrow \lambda_2 = 1.026\times10^{-7}\,m \Rightarrow 102.6\,nm$

$\frac{1}{\lambda_3} = R\left[\frac{1}{1^2} - \frac{1}{4^2}\right] = \frac{1.097\times10^7\times15}{16} \Rightarrow \lambda_3 = 0.972\times10^{-7}\,m \Rightarrow 97.2\,nm$.

31-15 **31-16** These are straight forward problems with "n" = 3

$p_n = p_3 = \frac{m_e 2\pi k e^2}{nh}$ with $m_e \equiv$ mass of electron.

$r_n = \left(\frac{h^2}{4\pi^2 m k e^2}\right) n^2$ $\quad k \equiv 9\times10^9\,\frac{Newton\,m^2}{Coulomb^2}$

$e = 1.6\times10^{-19}$ Coulombs

$L_n = r_n p_n$ $\quad n = 3$

$PE = -\frac{ke^2}{r_n}$ $\quad E_{Total} = -\frac{ke^2}{2r_n}$ $\quad h = 6.63\times10^{-34}$ Joule sec