Chris Hunt HW3 CH201

3.1) Determine wavelength of 96.8 MHz.

$\lambda = \frac{c}{F} = \frac{c\ m/s}{96.8\ MHz} \rightarrow 3.097\ m = 3.097 \times 10^9\ nm = 3.097 \times 10^{10}$ Angstrom

3.2) A Ham radio operator broadcasting on 60 m band is broadcasting at:

$F = \frac{c}{\lambda} = 4.99\ MHz = \boxed{5\ MHz\ \text{band}}$

3.3) Energy in Joules of a photon with $\lambda = 1.1$ Å

$E = \frac{hc}{\lambda} = \frac{hc}{1.1\ Å} = \boxed{1.8 \times 10^{-15}\ J}$

3.4) A gamma ray of Co-60 has an $E = 1.33\ MeV$ $1\ eV = 1.602 \times 10^{-19}\ J$

$\lambda = \frac{hc}{E} = \frac{hc}{1.33 \times 1.602 \times 10^{-19} \times 10^6\ J} = \boxed{9.32 \times 10^{-4}\ nm} = \lambda$

$F = \frac{c}{\lambda} \rightarrow \frac{c\ m/s}{9.32 \times 10^{-13}\ m} = \boxed{3.22 \times 10^{20}\ Hz} = F$

3.5) Use the Rydberg equation to find λ of a photon when an e^- in a H atom undergoes the following transitions:

a) $n_2 = 4 \rightarrow n_1 = 1$ $R = 1.0973715 \times 10^7\ m^{-1}$

$\lambda = \left|\frac{1}{R(1/n_1^2 - 1/n_2^2)}\right| \rightarrow \lambda = \left|\frac{1}{R(\frac{1}{1} - \frac{1}{16})}\right| = 972$ Å

b) $n_2 = 5 \rightarrow n_1 = 2$

$\lambda = \left|\frac{1}{R(1/n_1^2 - 1/n_2^2)}\right| \rightarrow \lambda = \left|\frac{1}{R(1/4 - 1/25)}\right| = 4339$ Å

3.6) Arrange the following e^- transitions for a H atom in order of decreasing λ

a) $\lambda = \left|\frac{1}{R(1/9 - 1/36)}\right| = 83.3$ Å b) $\lambda = \left|\frac{1}{R(1/9 - 1/4^2)}\right| = 84357$ Å c) $\lambda = \left|\frac{1}{R(1/16 - 1/60)}\right| = 14580$ Å

d) $\lambda = \frac{1}{R(1/1 - 1/4)} = 1215$ Å

$\boxed{b > c > d > a}$

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3.7) An electron in the $n=5$ level emits a photon wit $\nu = 2.342\times10^{14}$ Hz what n was it moved to?

$$\lambda = \frac{c}{\nu} = 1.281\times10^{-6}\,m$$

$$\lambda = \frac{1}{R(1/n_1^2 - 1/n_2^2)} = \frac{1}{\lambda R} = 1/n_1^2 - 1/n_2^2 = \frac{1}{n_1^2} = \frac{1}{\lambda R} + 1/n_2^2$$

$$\left(\frac{1}{n_1^2}\right)^{-1} = (.1111)^{-1} \rightarrow \sqrt{n_1^2} = \sqrt{9} \rightarrow \boxed{n_1 = 3}$$

The electron moved to $n=3$ from $n=5$

3.8) How many photons are need to of $\lambda = 700.0\,nm$ to transfer a minimum of 2.0×10^{-17} J in 20×10^{-3} s to see the color red?

1 photon of 700.0 nm λ generates $E = \frac{hc}{\lambda}$ Joules

$$E_p = \frac{hc}{700\,nm} = 2.84\times10^{-19}\,J$$

$$\#_p = \frac{E_{needed}}{E_p} = \frac{2.0\times10^{-17}\,J}{2.84\times10^{-19}\,J/\text{photon}} = 70.42 \rightarrow$$

$\boxed{\text{71 photons are needed in 20 milliseconds.}}$

3.9) Use Bohr's model to determine the energy recquired to remove an e^- from $n_s = 2$ in a H atom

$$\Delta E = -R_y \cdot Z_H^2\left(\frac{1}{n_f^2} - \frac{1}{n_s^2}\right)$$

$$\Delta E = -2.18\cdot10^{-18}\cdot 1^2\left(\frac{1}{\infty} - \frac{1}{4}\right)$$

$$\boxed{\Delta E = 5.45\cdot10^{-19}\,J \text{ recquired}}$$

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3.10) An H atom in state $n=1$ absorbs a photon of wavelength $\lambda_{p1} = 94.91\times10^{-9}$ m

As the electron returns to the ground state ($n_g = 1$) it first moves to an intermediate state n_1

This excitation emits a photon of $\lambda_{p2} = 1281\times10^{-9}$ m

a) What energy state did the electron reach? Find n_1

- Find energy of P2 using $E = \frac{hc}{\lambda}$

$$E = \frac{6.6262\times10^{-34}\,Js \cdot 2.99\times10^{8}\,m/s}{94.91\times10^{-9}\,m} = 2.09\times10^{-18}\,J$$

- Find n_1 using $\Delta E = -2.18\times10^{-18}\,J\left(\frac{1}{n_1^2} - \frac{1}{n_g^2}\right)$

$$2.09\times10^{-19}\,J = -2.18\times10^{-18}\,J\left(\frac{1}{n_1^2} - \frac{1}{1}\right)$$

$$-0.95756 = \frac{1}{n_1^2} - 1 \rightarrow \left(0.0424 = \frac{1}{n_1^2}\right)^{-1/2} \rightarrow 4.85 \approx 5$$

$\boxed{n_1 = 5}$ The electron reached the 5th energy level

b) $E = \frac{hc}{1281\times10^{-9}\,m} = -1.55\times10^{-19}\,J \rightarrow$ energy of second photon

$$-1.55\times10^{-19}\,J = -2.18\times10^{-18}\left(\frac{1}{n_2^2} - \frac{1}{5^2}\right)$$

$$+0.07094 = \frac{1}{n^2} - \frac{1}{25} \rightarrow \left(0.1109 = \frac{1}{n_2^2}\right)^{-1/2} = 3$$

$\boxed{n_2 = 3}$ The electron reached the 3rd energy level

c) The final emitted photon wavelength

$$\frac{hc}{\lambda} = \frac{-2.18\times10^{-18}}{hc} \cdot 1^2\left(\frac{1}{1^2} - \frac{1}{3^2}\right)$$

$$\left(\frac{1}{\lambda} = 7.33\times10^{6}\right)^{-1} \rightarrow 1.36\times10^{-7}\,m \cdot \frac{10^9\,nm}{1\,m} = 136.3\,nm$$

$\boxed{\lambda_{final} = 136.3\,nm}$

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3.11) a) $\Delta E = -2.18 \cdot 10^{-18} J (2^2)\left(\frac{1}{5^2} - \frac{1}{2^2}\right)$

$\Delta E = 1.83 \cdot 10^{-18} J$

$\boxed{1.83 \cdot 10^{-18} J \text{ would be required to move } He^{+1} \text{ ion from } n=2 \text{ to } n=5}$

b) $\Delta E = \frac{hc}{\lambda} \rightarrow \lambda = \frac{hc}{\Delta E}$

$\lambda = 1.082 \cdot 10^{-7} m \cdot \frac{10^9 nm}{1 m} = 108 nm$

$\boxed{\text{The photon's wavelength is 108nm which is in the ultraviolet range}}$