Homework 5

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1. **Estimations of de Broglie Waves**

(a) Boltzmann Constant in $\frac{\text{J}}{\text{K}} = 1.381 \cdot 10^{-23}$; Room temperature in K = 293

$$K_{avg} = \frac{3}{2} k_b T$$

$$p = \sqrt{2mK_{avg}}$$

$$\lambda_{avg} = \frac{6.626 \cdot 10^{-34}}{\sqrt{3 \cdot 28.013 \cdot 1.66 \cdot 10^{-27} \cdot 293.15 \cdot 1.38 \cdot 10^{-24}}}$$

$$\lambda_{avg} = 2.79 \cdot 10^{-11}[\text{m}] = .0279[\text{nm}]$$

(b) $.02[\text{eV}] = 3.204 \cdot 10^{-21}[\text{J}]$

$$\lambda_{avg} = \frac{h}{\sqrt{2mK}}$$

$$\frac{h}{\sqrt{2mK}} = \frac{6.626 \cdot 10^{-34}}{\sqrt{2 \cdot 1.675 \cdot 10^{-27} \cdot 3.204 \cdot 10^{-21}}}$$

$$\lambda_{avg} = 2.022 \cdot 10^{-10}[\text{m}] = .2022[\text{nm}]$$

(c) $1 \left[\frac{\text{m}}{\text{yr}}\right] = 3.17 \cdot 10^{-8} \left[\frac{\text{m}}{\text{s}}\right]$

$$\lambda_{avg} = \frac{6.626 \cdot 10^{-34}}{.001 \cdot 3.17 \cdot 10^{-8}}$$

$$\lambda_{avg} = 2.09 \cdot 10^{-23}[\text{m}] = 20.9[\text{ym}]$$

2. **de Broglie Wave of a Proton**

(a) $L = .01[\text{m}]$, so the round-trip distance for one oscillation is $2L = .02[\text{m}]$. Thus:

$$2L = n\lambda$$

Rearranging, we get:

$$\lambda = \frac{2L}{n}$$

(b)

3. e^- and e^+ Annihilation

(a)

$$\lambda_{e^-,e^+} = \frac{6.626 \cdot 10^{-34}}{9.109 \cdot 10^{-31} \cdot 3 \cdot 10^6} = .2425[\text{nm}]$$

(b)

$$E = mc^2 + \sum K$$

$$\left(9.109 \cdot 10^{-31}\right)\left(3 \cdot 10^8\right)^2 + \frac{1}{2}\left(9.109 \cdot 10^{-31}\right)\left(3 \cdot 10^6\right)^2$$
$$E = 8.2 \cdot 10^{-14}[\text{J}] = 511,803.7[\text{eV}]$$

$$\lambda = \frac{E}{hc} = \frac{511,803.7}{1240} = 412.75[\text{nm}]$$

$$E = pc^{1}$$
$$p = \frac{E}{c} = 2.73 \cdot 10^{-22}\left[\frac{\text{kg m}}{\text{s}}\right] = .511\left[\frac{\text{MeV}}{\text{c}}\right]$$

4. Uncertainty

(a)

(b)

[1] for photons