Chem 20A Worksheet 3

Lawrence Liu

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Problem 1

We have that

$$\lambda = \frac{h}{p} = \frac{h}{mv}$$

Thus we have that

$$v = \frac{m\lambda}{=} 3095274 m/s$$

And thus we have that the electron kenetic energy is

$$E = \frac{1}{2}mv^2 = \boxed{4.363 \cdot 10^{-18} J}$$

Problem 2

(a)

We have from the heisenberg uncertainty principle that

$$\Delta x \Delta p \geq \frac{\hbar}{2}$$

Thus we have that

$$m_e \Delta x \Delta v \geq \frac{\hbar}{2}$$

Thus we have that

$$\Delta v \geq \frac{\hbar}{2m_e \Delta x} = \boxed{57883 m/s}$$

(b)

We have that we can also rewrite the result from part (a) as

$$\Delta v \geq \frac{h}{4\pi m_e \Delta x}$$

So in our case of $h = 1js$ we would have that

$$\Delta v \geq \frac{1}{4\pi m_e \Delta x} = 8.735 \cdot 10^{37} m/s$$

Problem 3

(a)

For a electron in a box we have that the energy is given by

$$E_n = \frac{n^2 \pi^2 \hbar^2}{2m_e L^2}$$

Therefore we have that the ground state is

$$E_1 = \frac{\pi^2 \hbar^2}{2m_e L^2} = 3.355 \cdot 10^{-18} J$$

And the first excited state is

$$E_2 = \frac{4\pi^2 \hbar^2}{2m_e L^2} = 1.342 \cdot 10^{-17} J$$

Thus we have that the minimum energy required to excite the electron is

$$\Delta E = E_2 - E_1 = \boxed{1.007 \cdot 10^{-17} J}$$

(b)

We have that the wavefunction for the ground state is

$$\psi_1(x) = \sqrt{\frac{2}{L}}\cos(\frac{\pi x}{L})$$

Therefore the probability P_1 of finding the box inside the interval $[0.5, 0.7]$ angstrom is given by

$$P_1 = \int_{0.5}^{0.7} |\psi_1(x)|^2 dx = \boxed{\frac{2}{1.34\mathring{A}} \int_{0.5\mathring{A}}^{0.7\mathring{A}} \cos^2\left(\frac{\pi x}{1.34\mathring{A}}\right) dx}$$

Likewise we have that the wavefunction for the first excited state is

$$\psi_2(x) = \sqrt{\frac{2}{L}}\sin(\frac{2\pi x}{L})$$

Therefore the probability P_2 of finding the box inside the interval $[0.5, 0.7]$ angstrom is given by

$$P_2 = \int_{0.5}^{0.7} |\psi_2(x)|^2 dx = \boxed{\frac{2}{1.34\mathring{A}} \int_{0.5\mathring{A}}^{0.7\mathring{A}} \sin^2\left(\frac{2\pi x}{1.34\mathring{A}}\right) dx}$$