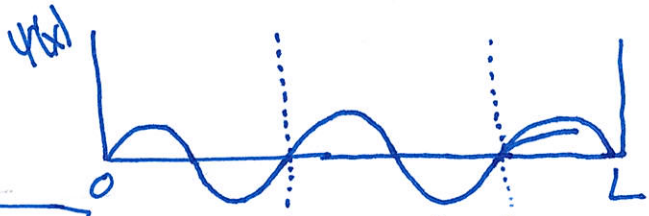
CH301H – Principles of Chemistry I: Honors
Fall 2017, Unique 50135

Quiz 3, 17 October 2017

A certain dye molecule can be estimated as an electron in a 1.9 nm box. When the electron is in the $n = 5$ state, what is the wavelength and momentum of the electron?

The following constants may be useful:
$\varepsilon_0 = 8.85 \times 10^{-12}\ C^{-2}\ J^{-1}\ m^{-1}$
$N_A = 6.022 \times 10^{23}\ mol^{-1}$
$e = 1.602 \times 10^{-19}\ C$
$h = 6.626 \times 10^{-34}\ Js$
$m_e = 9.1 \times 10^{-31}\ kg$

If $n=5$, there are 4 nodes



This is 2.5 wavelengths.

$$\lambda = \frac{L}{2.5} = \frac{1.9\,nm}{2.5} = \boxed{0.76\,nm = \lambda}$$

Two ways to solve for momentum:

1) $E_n = \frac{n^2h^2}{8mL^2}$; $E = \frac{1}{2}mv^2 = \frac{1 \cdot m^2v^2}{2m} = \frac{p^2}{2m}$

$$\frac{n^2h^2}{8mL^2} = \frac{p^2}{2m} \Rightarrow p = \sqrt{\frac{n^2h^2}{4L^2}} = \sqrt{\frac{(5)^2(6.626 \cdot 10^{-34}\,Js)^2}{4(1.9 \cdot 10^{-9}\,m)^2}}$$

$$\boxed{p = 8.72 \cdot 10^{-25}\ kg\,m\,s^{-1}}$$

2) $\lambda = \frac{h}{p}$; $p = \frac{h}{\lambda} = \frac{6.626 \cdot 10^{-34}\,Js}{0.76 \cdot 10^{-9}\,m} = \boxed{8.72 \cdot 10^{-25}\ kg\,m\,s^{-1} = p}$