Quiz 5 – Core Course 2002 Name: ______________________________

Please show your work, and your thinking, in the space provided. Be brief, but complete. Long, wandering answers typically demonstrate a lack of understanding…

$\hbar = 1.054x10^{-34}\,J\,s$

$h = 6.626x10^{-34}\,J\,s$

$m_e = 9.109x10^{-31}\,kg$

$c = 2.998x10^{8}\,m\,s^{-1}$

$k = 1.381x10^{-23}\,J\,\mathrm{K}^{-1}$

$e = 1.602x10^{-19}\,C$

$4\pi\varepsilon_o = 1.113x10^{-10}\,J^{-1}\,\mathrm{C}^2\,\mathrm{m}^{-1}$

$N_0 = 6.022x10^{23}\,mol^{-1}$

$\pi = 3.14159$

$$H_{translational} = \frac{-\hbar^2}{2m}\frac{d^2}{dx^2}$$

$$p_{translational} = \frac{\hbar}{i}\frac{d}{dx}$$

Particle in a 1D box

$$\psi_n = \left(\frac{2}{L}\right)^{1/2}\sin\left(\frac{n\pi x}{L}\right)$$

$$E_n = \frac{n^2h^2}{8mL^2} \qquad n = 1,2,3,\ldots$$

1D Harmonic oscillator

$$\psi_\upsilon = N_\upsilon H_\upsilon(y)e^{-\frac{1}{2}y^2} \quad y = \frac{x}{\alpha} \quad \alpha = \left(\frac{\hbar^2}{\mathrm{mk}}\right)^{1/4}$$

$$N_\upsilon = \left(\frac{1}{2^\upsilon\ \upsilon!\ \pi^{1/2}\ \alpha}\right)^{1/2} \quad H_\upsilon(\mathrm{y}) = \text{Hermite Polyn}$$

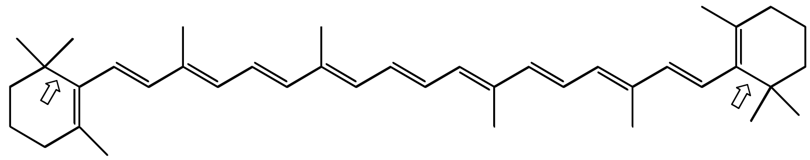
$$\mathrm{E}_\upsilon = \left(\upsilon + \frac{1}{2}\right)\hbar\omega \qquad \upsilon = 0,1,2,3\ldots$$

1. Consider the wavefunction: $\psi = k\hbar e^{ikx}$

   a) (20 points) Show that it is an eigenfunction of H

   b) (10 points) What can you conclude about the *motion* of an electron described by this wavefunction? Your conclusions should be both quantitative and qualitative.

2. (20 points) The chromophore which gives carrots their orange color is beta-carotene.



The color of tomatoes is due to a similar molecule, in which the rings have undergone scission where indicated. What color are tomatoes (***explain*** briefly)?

3. (25 points)An electron is confined to a one dimensional box of length L. What should the length of the box be in order for the electron's zero point energy to be equal to its rest mass energy of $m_e c^2$?

4. a) (15 points) The potentials below left show the scenario described for the simple one-dimensional particle in a box. Draw on top of the potentials, the functions for the n=1 (top) wavefunction and the n=2 (lower) wavefunction.

   b) (10 points) The potentials below right show a slightly modified potential in which one "wall of the box" is not at infinitely high potential. Draw the same wavefunctions for n=1 and n=2, but illustrating how the wavefunction will change in this new potential. Think about what you expect from the limits of classical behavior.