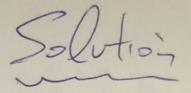
## PHY294 Quiz #1 (January 29th 2016)

Name (last, first): Student ID: Signature:



· 4 questions, 25 minutes.

· Closed book, closed notes and no calculators.

• Please write only in the Quiz paper (double-sided).

1. What is the deBroglie wavelength of a proton (mass  $m_p$ ) moving at 4/5 the speed of light? [Give your answer in terms of  $m_p$ , c and h.]

$$\lambda = \frac{h}{P} = \frac{h}{8mpv}$$

$$\delta = \frac{1}{\sqrt{1-(\frac{4}{5})^2}} = \frac{5}{3}$$

$$= \frac{h}{8mp} = \frac{3}{4mpc}$$

$$= \frac{3}{4mpc}$$

2. Use the Uncertainty Principle to estimate the minimum energy of the electron in a hydrogen atom. [Note: the orbital energy is given by  $E = p^2/2m_e - \alpha e^2/r$ , where p is the momentum, r the radius,  $m_e$  the electron mass,  $\alpha$  the Coulomb constant, and e the electron charge (magnitude).]

- 3. The ground-state wave function of a 1D harmonic oscillator is:  $\psi(x) = Ae^{-b^2x^2/2}$ , A and b are constants.
- (a) Does this quantum state have well-defined kinetic energy? [Give reason]
- (b) Write down an integral expression for the expectation value of its potential energy. [Do not solve]

$$Pf = -it \left[ \left( \left( -\frac{2}{2}b^{2}x \right) \right]$$

$$P^{2}f = -b^{2}f^{2} \left[ -4 - \left( -4b^{2}x \right)x \right] \neq constant - 4$$

$$-i \quad kE = \frac{P^{2}}{2m} \text{ is not well defined.}$$

$$i.e. \quad f \text{ is not an eigenstate of } P^{2}.$$

$$B \quad \langle PE \rangle = \frac{1}{2} k \langle \chi^{2} \rangle = \frac{1}{2} k A^{2} \int_{e}^{-b^{2}x^{2}} dx$$

$$\int_{e}^{b} pring constant$$

- **4.** Consider an electron in a 1D infinite-potential square well of width L centered at x=L/2. Let it be in an equally-mixed superposition of the ground (n=1) and  $2^{nd}$ -excited (n=3) states.
- (a) Prior to any measurements, does the expectation value  $\langle p^2 \rangle$  depend on time? [Give reason]
- (b) After a measurement that finds the electron in the n=3 state, what is  $\Psi(x,t)$  [in term of  $m_e, L, h$ ]?

A No: 
$$\langle P^2 \rangle = 2m \langle E \rangle$$
 and  $\langle E \rangle = \frac{E_1 + E_3}{2}$   
Note:  $\overline{Y} = \frac{1}{2} \overline{Y}_{n=1} + \frac{1}{12} \overline{Y}_{n=3}$ ,  $\overline{Y}_n = \frac{1}{12} \overline{Y}_n = \frac{1}{12} \overline{Y$