SAMPLE EXAM 2

1. A proton is in an infinite square well potential for which: (15 pts)

   $U(x) = 0$ for $0 < x < L$

   $U(x) = \infty$ for $x < 0$ and $x > L$

   Take the length of the square well potential to be $L = 10^{-15}$m.

   a) Derive the wavefunction for the proton inside the well.
   b) Derive an expression for the momentum and energy.
   c) Calculate the ground state energy in MeV.
   d) Make an energy level diagram and find the wavelengths of the photons emitted for all transitions beginning at state n=3 or less and ending at a lower energy state.

2. An electron in the hydrogen atom is in the first excited state (n=2). (20 pts)
   a) Obtain an expression for all the spatial wavefunctions in this state.
   b) Obtain an expression for the radial probability density associated with each wavefunction in part (a).
   c) Obtain an expression for the probability density associated with each wavefunction in part (a). Do these probability densities depend on time? Explain.
   d) Graph the radial probability densities obtained in part (b) and label where the electron is most likely to be found.
   e) Sketch the probability densities (electron clouds) found in part (c) and label where the electron is most likely to be found.
   f) What are the physical interpretation of the wavefunctions in part (a), the radial probability densities in part (b), and the probability densities in part (c)?
   g) Where is the electron most likely to be found in the n=2 state?

3. The wavefunction for a particle is given by

$$\Psi(x,t) = Ae^{\alpha x^2 - i\omega t}.$$

a) Describe the physical significance of $|\Psi(x,t)|$.

b) Describe the physical significance of $|\Psi(x,t)|^2$.

c) Write an expression for the probability of finding the electron in the interval (-2α, 2α). Leave you answer in terms of the constant A. **Do not evaluate your expression!**

d) **If** the wavefunction $\Psi(x,t)$ was normalized, what would be the probability of finding the particle in the interval $(-\infty, +\infty)$?

4. Calculate the uncertainty product ΔrΔp for the 1s electron of hydrogen.