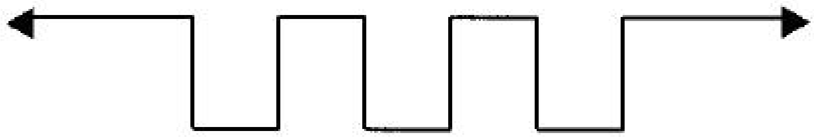
Exam 1 **CHEM 1410** **K. Jordan**

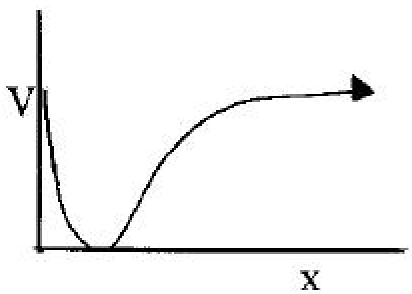
Name ____

1. (16 pts.) Sketch the ground and first excited state wavefunctions for the following potentials.

a)



b)



2. (18 pts) Suppose you lived in a one-dimensional world. In this world the hydrogen atom would be one-dimensional (*i.e.*,the only relevant variable is x).

a) Write down the Schrodinger equation for the one-dimensional H atom.

b) Show that $\psi = xe^{-\alpha x}$ is a solution to this equation.

c) What is the energy associated with the above wavefunction?

3. (18 pts) Which of the following statements is true. (Circle the true statements.)

a) The H atom has an infinite number of bound energy levels.

b) ψ^2 is always real.

c) The uncertainty principle tells us that the energy of a rigid rotor cannot be zero.

d) There is a non-zero probability that an electron in the hydrogen atom is found at classically forbidden distances from the proton.

e) $\hat{\mathscr{L}}^2$ and $\hat{\mathscr{L}}_x$ commute for the rigid rotor problem.

f) Any time a system has some symmetry, there will necessarily be degenerate levels.

4. (18 Pts) Consider the two dimensional Harmonic oscillator with the potential energy $\frac{1}{2} k\,(x^2+y^2)$.

a) Write the wavefunctions for the ground state and the first two excited states.

b) What are the energies of these three states?

c) What is the vibrational zero-point energy for this system.

5. (18 Pts) For the one-dimensional particle-in-the-box problem, calculate the average energy using the wavefunction $\psi(x) = Lx - x^2$, where L is the box length. (In other words, assume that you do not know the exact wavefunction, and use the one given above instead.)

6. (12 Pts) In problem 5, the approximate wavefunction $\psi(x) = Lx - x^2$ was employed for the ground state of the particle in the box. Suggest an approximate wavefunction for the first excited state wavefunction for this problem.