Examination 1 **October 13, 1993**

Chemistry 262 **Dr. Jay H. Baltisberger**

Name: _____

1. What, specifically, leads to quantization of energy levels in the harmonic oscillator problem? (15 points)

2. Which of the following two functions is an eigenfunction of the momentum operator and what is the eigenvalue for this function? (20 points)

$$\hat{p}_x = \frac{\hbar}{i}\frac{d}{dx}$$

$$\psi_1 = A\exp(-ikx)$$

$$\psi_2 = Ax\exp\left(-kx^2\right) + B\exp\left(-kx^2\right)$$

Name: _____

3. Which of the following functions can not be a real world wavefunction and why? (15 points)

$$\psi_1 = \frac{A}{x}\exp(-ix) \qquad \psi_2 = A|x| \qquad \psi_3 = \begin{cases} A\exp(x) & x \le 0 \\ 2A\exp(-ikx) & x \ge 0 \end{cases}$$

4. How would you calculate the mean square position expectation value for the second excited state particle in a box. (20 points, 5 Bonus points if you perform integration using the integral provided)

$$\psi_n = \frac{1}{\sqrt{L}}\cos\frac{n\pi x}{2L} \qquad \int x^2\cos^2 x\,dx = \frac{x^3}{6} + \frac{2x^2-1}{8}\sin 2x + \frac{x\cos 2x}{4} + C$$

Name: _____

5. What is the energy for a paricle with the wavefunction below in a one dimensional harmonic oscillator potential. (5 points for setting up derivatives, 5 points for actually performing the correct differentiation, 5 Bonus points for setting the additional calculation of the mean square momentum of this state)

$$\psi_1 = N_2\left(\frac{4x^2}{\alpha^2} - 2\right)\exp\left(-x^2/2\alpha^2\right) \qquad \alpha^2 = \hbar/m\omega \qquad \hat{H} = \frac{-\hbar^2}{2m}\frac{d^2}{dx^2} + \frac{m\omega^2 x^2}{2}$$

Name: _____

6. Draw pictorally the wavefunctions for particles with the energy levels indicated below (E_1 and E_2) for the following potential. Notice that energy state E_1 is less than the middle potential V_2 but larger than the other two potentials V_1 and V_3. Energy state E_2 on the other hand is larger than V_1, V_2 and V_3. Indicate where the wavelength of the wavefunction will be largest and smallest. Also, indicate where the wavefunction has a sinusoidal form and where it has an exponential form. (20 points)