

Examination 1
Chemistry 262

October 12, 1998
Dr. Jay H. Baltisberger

Name: _____

Please answer 6 of 7 questions, show all calculations - 30 points each, 180 total, graded out of 175.

$$R = 0.08256 \text{ L atm mol}^{-1} \text{ K}^{-1} N_A = 6.02 \times 10^{23} \quad k = 1.381 \times 10^{-23} \text{ J K}^{-1}$$

1. Show that $f = 8 e^{5x}$ is an eigenfunction of the operator d/dx . What is the eigenvalue?
2. Calculate the de Broglie wavelength of an oxygen molecule (MW 31.9988 g/mol) at 300 K ($E = 3 k T / 2$). How does this compare to the average distance between oxygen molecules in a gas at 300 K and 1 atm?
3. Assuming the molecule $^1\text{H}^{127}\text{I}$ is modeled with the harmonic oscillator and the force constant is $k = 317 \text{ N m}^{-1}$, calculate the fundamental vibrational frequency. What is the frequency if the ^1H is replaced by a ^2H ?
4. What is the resulting wavefunction when the $x^2 - 1$ (remember how we defined x in terms of raising and lowering operators) operator is applied to the ψ_5 harmonic oscillator wavefunction? Use only symbolic math to solve this one in terms of ψ_n 's only.
5. Graphically draw the approximate wavefunctions and energy level spacing for the first 3 levels of a potential energy of $V(x < 0) = 0$ and $V(x > 0) = x$.
6. In your own words, describe the difference between normalization and orthogonal, as applied to wavefunctions.
7. What is the probability of finding an electron within 1 \AA of the center of the ground state for a particle in a 10 \AA box?