Physical Chemistry Test 1 Name_____
Spring 2006
Prof. Shattuck

1. (5pts) Which of the following particles has a higher kinetic energy?

(a)  (b) 

*******Answer five (5) of the following seven (7) questions. If you answer more than 5 cross out the one you wish not to be graded, otherwise only the first 6 will be graded.*********

2. (10pts) What are the relative intensities for the lines in a quartet in an NMR spectrum (all equivalent neighbors)?

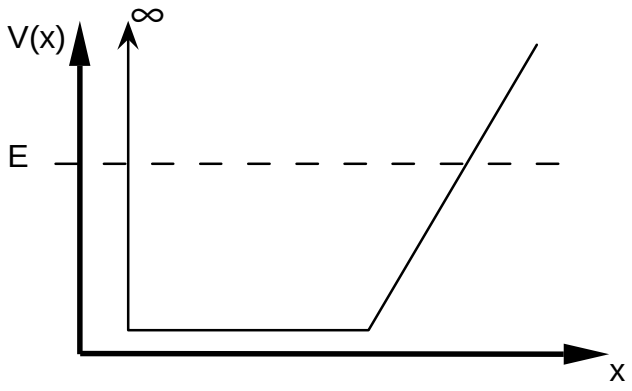
3. (10pts) What is the degeneracy of the $l = 1$ level of the rigid rotor? (Or J =1, which ever quantum number is used for angular momentum)

4. (10pts) Find the z-component of the angular momentum $(l_z)_{for}$ the rigid-rotor given the spherical harmonic wavefunction $Y_{1,1} = (3/8\pi)^{1/2} \sin\theta\, e^{i\phi}$.

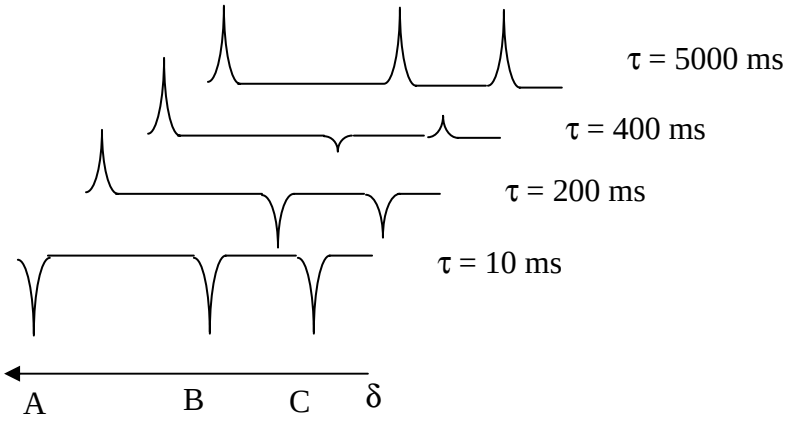
5. (10pts) Two restrictions are placed on the solutions to the Schrödinger equation that take the form of integrals. Name the two restrictions, the two integrals, and their values that define these restricitions.

6. (10pts) Consider the possible particle in a box wavefunction $\psi = A \cos(\frac{n\pi x}{a})$, where n is the quantum number and a is the box length. ψ is an eigenfunction of the Hamiltonian, but ψ is <u>not</u> an allowable wavefunction. Why is this ψ not an allowable wavefunction? (Hint: sketch this wavefunction).

7. (10pts) Draw a reasonable guess for the wavefunction for a particle subject to the potential energy graphed below. Assume that the energy of the particle, E, is as shown and that the particle is in the <u>n = 2 level</u> (i.e. its <u>first</u> excited state--not its ground state, n=1).



8. (10 pts) Which chemical environment has the shortest T_1 relaxation time? The pulse sequence used was 180°-τ-90°-FID.



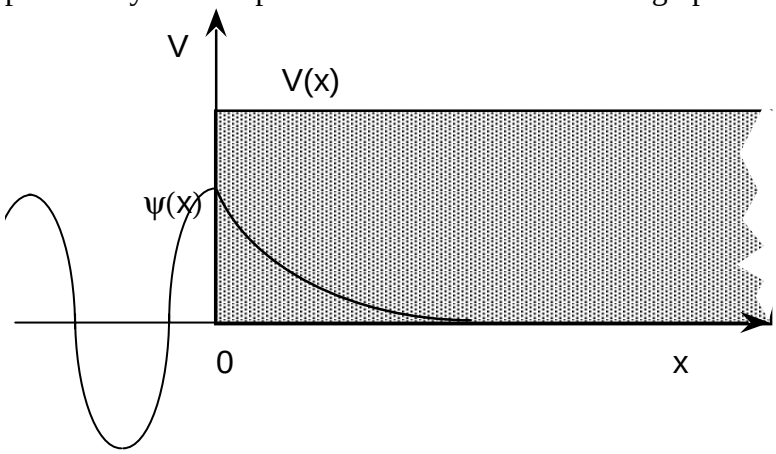
Part 2. Answer all of the following questions.

9. (15pts) (a)Show that $\psi = N e^{-\alpha r}$ is an eigenfunction of the operator $\left(\frac{\partial^2}{\partial r^2}\right)$.

(b) What is the eigenvalue?

10. (15pts) Determine the average momentum for a particle in a one-dimensional box in its n=2 quantum state. Just set up the problem--don't do the math, but remember to specify everything necessary to finish the problem.

11. (15pts) The wavefunction inside a long barrier of height V is $\psi = N e^{-\kappa x}$. Calculate the probability that the particle is inside the barrier. A graph of this system is shown below.



12. (Completely lacking credit) If you woke one morning to find yourself confined-in-a-box, would you

a) Wave hello?
b) Tunnel to freedom?
c) Degenerate?
d) Get a cold in your nodes?
e) Make a transition to a higher state of awareness?
f) Probably stay in the box?
g) Relax into deep sleep?
h) Continue moving even if it gets very-very cold?
i) Try to get excited when the sun comes up?
j) Consider this a momentum occasion?
k) Have high expectations?
l) Make sure everything is as normalized as possible?
m) Greet your reflection in the mirror?
n) Try to make some wiggle-room?
o) Do an exercise to adjust the curvature in your back?
p) Dream of the dels of home?

Anyway, it would be a $\hbar e l(l+1)$ of a time if you ever got around to it.