Chemistry Department
Smith College

Chm331 **Fall, 2010**

Quiz One, Conceptual

Name KEY

You are to take this examination in the library. It is closed notes, closed text, without assistance from the web or other people. You should spend no more than 60 minutes on this quiz.

1. (10) The probability of finding a value of x over a range of -5 to 5 is given by the function g(x). Write a symbolic expression for the expectation value of x^3, $< x^3 >$.

Is a probability, don't need $\int \psi^* \psi$ stuff

Normalize $g(x)$ $\int A g(x)\, dx = 1$

$$\langle x^3 \rangle = \int A\, g(x)\, x^3\, dx$$

2. (10) a. The quantum mechanical operator associated with the momentum in the x direction can be written:

$(\hbar/i)\ d/dx$

Give the symbolic expression for the expectation value of the momentum in the--pay attention--**y** direction, $\langle p_y \rangle$, for the wave function $\psi(x, y, z)$.

Normalize Ψ_1, Ψ_n

$$\langle p_y \rangle = \int \Psi_n^* \frac{\hbar}{i} \frac{\partial}{\partial y} \Psi_n \, dy$$

b. Write a symbolic expression for the expectation value of the energy for a system with wave function $\phi(x)$ and with V = 0.

Normalize $\phi(x) \Rightarrow \phi_n(x)$

$$\langle E \rangle = \int \phi_n^* \left(-\frac{\hbar^2}{2m}\right) \frac{\partial^2}{\partial x^2} \phi_n(x) \, dx$$

3. (9) For each of the following, indicate the eigenvalue corresponding to the operator (which is enclosed in parentheses) and the function given. A possible answer is "This is not an eigenfunction/eigenvalue problem."

a. $(d/dx)\ 3x^2 =$ $6x$ NOT EF/EV

b. $(d^3/dx^3)\ \mathrm{Sin}[k\,x] = -k^3 \cos[kx]$ where k is a constant.

NOT EF/EV

c. $(d/dz)\ \mathrm{Exp}[-b\,z] =$ where b is a constant.

$-b e^{-bz}$ eF/eV eV = −b

4. (12) Two eigenfunctions of the parve on a pole (which starts at x = 0 and goes to x = L) are given below. (a) What does it mean to say that they are orthogonal?

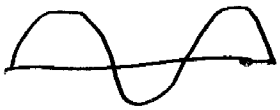
ψ_1 Sqrt[2/L] Sin[3 Pi x/L] and ψ_2 Sqrt[2/L] Sin[8 Pi x/L]

$\int \psi_1^* \psi_2 \, dx = 0$

(b) Are they orthogonal? Why or why not? HINT: You do not need to do any mathematics to answer this question.

e.f. of $\hat{H}$ are orthogonal.

(c) Make a rough sketch of the first of these functions.



n = 3

5. (9) de Broglie first suggested a relationship between the particle - like "properties" of a parve and the wave - like "properties." What is that relationship?

$$p = \frac{h}{\lambda}$$