Name: _____ **Entry #:** _____ **Gp. #:** _____

1. *(1 point)* Two different physical observables are represented by the operators $\hat{A}$ and $\hat{B}$. In quantum mechanics, it is possible to know, exactly and simultaneously, the values of both of these measured quantities only when $[\hat{A}, \hat{B}] = 0$ **or** $\hat{A}$ **and** $\hat{B}$ **commute**.

2. *(1 point)* A particle is in an infinite square well potential with walls at $x = 0$ and $x = L$. If the particle is in the state $\psi(x) = A \sin\left(\frac{n\pi x}{L}\right)$, where A is a constant, the mathematical expression for the probability of finding the particle between $x = L/n$ and $x = 2L/n$ is $\frac{\int_{L/n}^{2L/n} \psi^* \psi \, dx}{\int_0^L \psi^* \psi \, dx}$ **or** $\frac{A^2 \int_{L/n}^{2L/n} \sin^2\left(\frac{n\pi x}{L}\right) dx}{A^2 \int_0^L \sin^2\left(\frac{n\pi x}{L}\right) dx}$ **or** $\frac{1}{n}$.

3. *(1 point)* The term in the Hamiltonian of He atom which makes the analytic solution of the Schrödinger equation impossible has the mathematical form $\frac{e^2}{4\pi\epsilon_0 r_{12}}$ **or** $\frac{e^2}{4\pi\epsilon_0 |\vec{r}_1 - \vec{r}_2|}$.

4. *(2 points)* A possible value of c in the normalized molecular orbital $\psi = c\phi_1 - \frac{1}{\sqrt{3}}\phi_2$, where ϕ_1 and ϕ_2 are normalized atomic orbitals on two different atoms, is $\frac{S + \sqrt{S^2+2}}{\sqrt{3}}$ **or** $\frac{S - \sqrt{S^2+2}}{\sqrt{3}}$.

5. *(1 point)* The difference in energy between the lowest two non-degenerate states for a particle in a cubic box of length L is $\frac{9h^2}{8mL^2}$.

6. *(2 points)* The ratio of molecules distributed between two states is 9.22×10^6 at 300 K. The difference in energy of the two states in kJ mol^{-1} is $40.0\,\text{kJ mol}^{-1}$. ($k_B = 1.381 \times 10^{-23}\,\text{m}^2\,\text{kg}\,\text{s}^{-2}\,\text{K}^{-1}$)

7. *(2 points)* The angle of orientation (in degrees) of the angular momentum vector with respect to the z-axis for the state with the angular function $\sin^2\theta \cos\theta e^{-2i\phi}$ is $125.26°$.

Solution Version n. 1

1. $[\hat{A}, \hat{B}] = 0$ or $\hat{A}$ and $\hat{B}$ commute
2. $\frac{\int_{L/n}^{2L/n} \psi^* \psi \, \mathrm{d}x}{\int_0^L \psi^* \psi \, \mathrm{d}x}$ or $\frac{A^2 \int_{L/n}^{2L/n} \sin^2\left(\frac{n\pi x}{L}\right) \mathrm{d}x}{A^2 \int_0^L \sin^2\left(\frac{n\pi x}{L}\right) \mathrm{d}x}$ or $\frac{1}{n}$
3. $\frac{e^2}{4\pi\epsilon_0 r_{12}}$ or $\frac{e^2}{4\pi\epsilon_0 |\vec{r_1} - \vec{r_2}|}$
4. $\frac{S+\sqrt{S^2+2}}{\sqrt{3}}$ or $\frac{S-\sqrt{S^2+2}}{\sqrt{3}}$
5. $\frac{9h^2}{8mL^2}$
6. $40.0\,\mathrm{kJ\,mol^{-1}}$
7. $125.26°$