MidTerm II - Modern Physics for Engineers

November 2, 1998

Test No. ______________________

Name:______________________

S.S. No.:______________________

Do all work in this exam booklet. Use the backs of the sheets if necessary. Please compute all numerical answers using your calculator if necessary.

Good luck.

EQUATION SHEET

$$\int_{-\infty}^{\infty} e^{-\frac{x^2}{2\sigma^2}}\, dx = \sqrt{2\pi}\sigma \qquad \int_{-\infty}^{\infty} x^2 e^{-\frac{x^2}{2\sigma^2}}\, dx = \sqrt{2\pi}\sigma^3$$

$$\int_0^\pi \sin^2 x\, dx = \frac{\pi}{2} \qquad \int_0^\pi x^2 \sin^2 x\, dx = \frac{4\pi^3}{3} - \frac{\pi}{2} \qquad \int_0^\pi \sin x \cos x\, dx = 0$$

$$E = (n + \frac{1}{2})\hbar\omega \qquad E = \frac{\hbar^2\pi^2 n^2}{2mL^2} \qquad E = -\frac{\hbar^2}{2a_0 n^2}$$

$$V = \frac{1}{2}m\omega^2 \qquad V = -\frac{kq^2}{r}$$

$$\hbar = 1.055 \times 10^{-34}\ \mathrm{J \cdot s} = 4.136 \times 10^{-15}\ \mathrm{eVsec}$$

Problem I Short Answers - 5 points each

1. An electron is captured in a potential of the form: $V = \infty$ for $x \leq 0$ and $V = V_0 x$ for $x > 0$. Draw the potential and the wave function for the second excited state.

2. Describe an experiment which shows the particle nature of light.

Problem I (continued)

3. If a particle's average x position is 0 and has $\left\langle x^2 \right\rangle = 1$ nm^2, what is the minimum uncertainty to which its x momentum can be measured?

4. The wave function for the first excited state for a particle in a harmonic oscillator potential ($V = \frac{1}{2}m\omega^2 x^2$) is

$$\Psi(x) = \frac{\sqrt{2}\left(\frac{m\omega}{\hbar}\right)^{3/4}}{\pi^{1/4}} x e^{-\frac{m\omega x}{2\hbar}}.$$

Write the integral that you would have to evaluate to find the average position - momentum correlation $\langle xp \rangle$. (Do not evaluate the integral!)

Problem II - 20 points

A particle is is confined by the following potential: $V = \infty$ for $x \leq 0$ and $x \geq a$ and $V = 0$ for $0 < x < a$. What differential equation do you need to solve to find the wave function for the particle? What are the boundary conditions? Find the normalized wave function and the energy of the ground state for this potential. What is the RMS momentum ($\triangle p$) for this state?