Physics 308 Introduction to Quantum Mechanics Spring 2005

Homework 13 (Extra Credit), Due AT BEGINNING OF CLASS, Friday 6 May

For each of the following questions write an essay of 100-200 words, paying attention to writing complete sentences with standard grammar and spelling. You may use equations and figures if they can help make your discussion clear. The point is to convey basic ideas to students with the preparation you had at the beginning of this course. When you are asked to explain something, this does NOT mean you have to give a proof.

1. Describe how the two assumptions for photons $E = h\nu$ and $\rho = [\epsilon_0 \vec{E}^2 + \vec{B}^2/\mu_0]/8\pi h\nu$, both at least implicit in Einstein's 1905 paper on particle phenomena for light, give single-particle quantum mechanics and so a natural introduction to all quantum mechanics. [Here ρ is the number of photons per unit volume.]

2. Describe the magic numbers for closed shells in atoms, on the assumption that the forces between electrons can be neglected. What are the qualitative changes when electron screening of the positive nuclear charge is taken into account?

3. Describe the closest quantum-mechanical harmonic-oscillator solution to the behavior of a classical harmonic oscillator, whose coordinate goes back and forth with sinusoidal time dependence. What is the crucial difference between this solution and the classical one? When is that difference unimportant?

4. Two basic ideas in quantum mechanics are the notion that phase space is quantized, that is, a finite area h in (x, p) space is needed to accommodate a possible state of the system, and the uncertainty principle which says that the product $\delta x \delta p$ must be no smaller than $\hbar/2$. Explain why it is natural that one involves h and the other $\hbar$.

5. Imagine a solution of the Schrödinger equation with energy E. Suppose that the potential in the equation is $V = 0$ for $x < 0$ and $V = V_0 > E$ for $x > 0$. Discuss the different results in classical and quantum physics for the possible presence of a particle in the region $x > 0$.