Physics 214b-2008 Walter F. Smith Final Exam Coverage

IMPORTANT: This exam will be truly cumulative, i.e. it will cover material from the entire semester. For example, it will cover material such as the quantum nature of light that we discussed back in chapter 1. However, there will be <u>some</u> extra emphasis on the material since exam 2, since you've not yet been tested on that.

Material covered since exam 2:

Book: Ch. 6 and sections 7.1-7.3, plus appendices B2 and B3.. **Assignments:** Assignments 10 and 11

Lectures: 27-38 (Friday 4-4-08 through Friday 5-2-08)

Equation sheet: You should prepare an equation sheet with up to 60 equations for use during the exam. No text or pictures allowed on this.

Three-dimensional quantum mechanics in Cartesian Coordinates

- 3D version of the Hamiltonian
- 3D infinite square well: separation of variables, energy eigenfunctions and eigenvalues

Quantum mechanics for radially-symmetric potentials

- Spherical coordinates
- The Laplacian in spherical coordinates
- **Can find simultaneous eigenfunctions for $\hat{H}$, $\hat{L}^2$, and $\hat{L}_z$**
- Deriving the expressions for $\hat{L}_x, \hat{L}_y$, and $\hat{L}_z$ from $\mathbf{L} = \mathbf{r} \times \mathbf{p}$
- **Commutators for $\hat{L}_x, \hat{L}_y$, and $\hat{L}_z$, and what they mean**
- Expression for $\hat{L}^2$
- The Hamiltonian in spherical coordinates
- Separation of radial and angular coordinates
- **Eigenfunctions and eigenvalues of $\hat{L}_z$**
- **Eigenvalues of $\hat{L}^2$**
- Be ready to use the recursion relation to create the eigenfunctions of $\hat{L}^2$
- Be ready to reproduce the argument for why we must terminate the power series for the eigenfunctions of $\hat{L}^2$, and how this leads to the eigenvalues of $\hat{L}^2$
- **Spherical harmonics:**
  - ***Know that they represent the eigenfunctions of $\hat{L}^2$ and of $\hat{L}_z$, and the angular part of the eigenfunctions of the Hamiltonian.**
  - ***Know what the subscripts mean.**
  - *A table of the spherical harmonics will be provided for you on the exam.
  - ***Orthonormality**
  - ***Superpositions of spherical harmonics (e.g. problem 6.25)**
- **Know the relation between the magnetic quantum number m_ℓ and the azimuthal quantum number ℓ**
- **Relation between $|\mathbf{L}|$ and ℓ**
- **Relation between L_z and m_ℓ**
- **Cone picture for orbital angular momentum: be ready to explain what this means, and how we know that the orbital angular momentum vectors lie on a cone**

Topics continue on the next page

Hydrogenic atoms

The radial equation, including both the version in terms of R and the version in terms of u

Meaning of "centrifugal barrier"

Be ready to use the recursion relation to generate the eigenfunctions for the radial equation

Be ready to reproduce the argument for why we must terminate the power series for these eigenfunctions, and how this leads to the energy eigenvalues

Equation for the energy eigenvalues

Relation between the principle quantum number *n* and the azimuthal quantum number ℓ

Know what the subscripts mean on the *R* functions, e.g. R_{10}

A table of the R functions will be provided on the exam.

Radial probability density: what it means, how to calculate it given *R*

Zeeman Effect

Relation between μ and **L**

$V_{mag} = -\mu \cdot \mathbf{B}$

How energy is modified in the presence of B

Spectroscopy

Connection between spacing of energy levels and energy of photon that is emitted or absorbed

Spin

Stern-Gerlach experiment

Be ready to explain how it separates a beam depending on the magnetic moment along the axis chosen

Why the results of the Phipps-Taylor experiment prove that there must be spin

Relation between $|\mathbf{S}|$ and *s*

Relation between S_z and m_s

Relation between m_s and *s*

Value of *s* for electron

Cone picture for spin: be ready to explain what this means, and how we know that the orbital angular momentum vectors lie on a cone

g factor

Column vector notation for spin

Matrix representation for $\hat{S}_x, \hat{S}_y$, and $\hat{S}_z$

Commutators for $\hat{S}_x, \hat{S}_y$, and $\hat{S}_z$, and what they mean

Superposing eigenstates of one spin operator to get the eigenstates of another. (*e.g.* superposing χ_+ and χ_- to get χ_{x+}.)

Relation between Stern-Gerlach-type experiments and above superpositions

Multiparticle Quantum Mechanics

Interpretation of the multiparticle wavefunction

Creating a multiparticle wavefunction from single particle wavefunctions for distinguishable particles

Indistinguishability

Parity operator

Be able to reproduce the complete argument for why indistinguishability requires that $\hat{P}_{12}\Psi(\mathbf{r}_1, \mathbf{r}_2) = \pm\Psi(\mathbf{r}_1, \mathbf{r}_2)$

Symmetrizing and antisymmetrizing combinations of one-particle wavefunctions to create multiparticle wavefunctions for indistinguishable particles

Spin-statistics theorem

Assuming the Spin-statistics theorem is correct, be able to reproduce the complete argument leading to the Pauli exclusion principle.

Antisymmetrizing either the spatial part of the wavefunction or the spin part

Singlet and triplet states

"Building up" or "Aufbau" principle