Physics 4261: Homework 1

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This homework is devided into two sections, quick problems and some problems from the book.

Quick Problems

For this section, I don't want you to necessarily *solve* the problems just set it up. Don't pore over any references either, and if you don't know what something means, just write it, e.g. "I don't know what a term symbol is". Do not spend more than 5 minutes per problem on this. **In addition, please tell me which of the 12 learning objectives on the syllabus (if any) you feel confident you already know**.

1.1. **Atomic configurations and term symbols**

(a) Write down the electron configuration for the ground state of carbon ($Z = 6$).

(b) What are the possible term symbols for this configuration?

(c) What are the allowed angular momenta for each term?

1.2. **Angular momentum addition**
Let **J** and **I** be two angular momentum operators, with $\mathbf{J}^2 = 3/4$ (that is, $J = 1/2$), and $\mathbf{I}^2 = 15/4$ (that is, $I = 3/2$).

(a) What are the allowed values (m_J) of J_z?

(b) What are the allowed values (m_I) of I_z?

(c) Let $|1/2\rangle_I$ denote the state with $m_I = 1/2$. What is the state $\hat{I}_+|1/2\rangle_I$, where $\hat{I}_+$ is the raising operator?

(d) Take $\mathbf{F} = \mathbf{J} + \mathbf{I}$. What are the allowed values of $\mathbf{F}^2$?

1.3. **Schrödinger equation**

(a) Write down the Schrödinger equation for three dimensions in Cartesian coordinates.

(b) Write down the Schrödinger equation for three dimensions in spherical coordinates.

(c) Using the results of 1.3b use separation of variables write three equations for the radial (r), polar (θ), and azimuthal (ϕ) coordinates.

1.4. **Perturbation theory** Consider a Hamiltontian H_0 with eigenstates $|A\rangle, |B\rangle, |C\rangle$ and eigenvalues A_0, B_0, C_0. Given a small parameter λ and another Hamiltonian H_1

(a) Find the eigenvalues of $H' = H_0 + \lambda H_1$ to first order.

(b) What if $\epsilon_0 = \epsilon_1 \neq \epsilon_2$? Let A_1 etc. be the eigenvalues of H_1.

(c) What if all unperturbed energies are equal?

Book Problems

- 1.1
- 1.5
- 1.12
- 1.13