

Midterm Quiz: Atomic and Molecular Physics 475
March 9, 2011

Use of text book (Foot) permitted. Total 44 points. Individual values follow each question. Try and resist the temptation to look up all of the answers or you will run out of time. The written answers don't need to be long; they need to convince me that you know and understand the answer.

1. Give some evidence for the atomic theory of matter with names of prominent scientists. (Doesn't need to be complete but I would like 2 concrete pieces of evidence/contributions and show the relation to atomic theory.) (6)
2. What is the Zeeman effect? By explicit calculation give a scale for the frequency splitting between optical modes with $B = 1$ T. What are the 3 modes of oscillation when a magnetic field is applied to an oscillating electron (eigenvectors and eigenfrequencies) and how are they named? How are these modes related to the selection rules for m for electric dipole transitions in hydrogen? (10)
3. Express y/r in terms of spherical harmonics and explicitly demonstrate the equality. (4)
4. Give an example of a metastable state in hydrogen. Why is it metastable? Label this state as appropriate for LS coupling (4)
5. What is *fine structure*? Physically (not just the formula) why is the degree of fine structure splitting so much bigger in lead than in hydrogen? Referring to Fig. 1.3 where is fine structure evident? How big is it in this case? (6)
6. In our discussion of excited states of helium we used degenerate perturbation theory. Why? Give the expressions for the energy shifts and the names that go with them in the early part of Foot Chapter 3. What modification is made to the perturbing Hamiltonian later in Chapter 3 and how is that modification related to the energy levels shown in Foot Fig. 3.4? (8)
7. Don't calculate it but include the correct expressions for the R functions in equation 3.31 to give a closed expression for J_{1s2p} for helium (Be careful with the Z -values.) (6)