PHY 491 - 2013

Atomic, Molecular, and Condensed Matter Physics

Problem Set 5

1. Show that the vector potential of a uniform magnetic field $\mathbf{B}$ can be written as $\mathbf{A}(\mathbf{r}) = -\frac{1}{2}\mathbf{r} \times \mathbf{B}$. Find $\boldsymbol{\nabla} \cdot \mathbf{A}$. (3 pt) Consider a particle with charge q and mass m in a static electromagnetic field. The Hamiltonian of the particle is $H = \frac{1}{2m}[\mathbf{p} - q\mathbf{A}(\mathbf{r})]^2 + qV(\mathbf{r})$. Derive the equation of motion. (3 pt)

2. Find the values of S, L, and J in the ground state for (a) a half-filled sub-shell with momentum l (in particular, a half-filled d-subshell), and (b) a subshell one electron short of being half-filled (8 pt)

3. Assume that the energy of an atom with given J, J_z in a magnetic field $\mathbf{B} = B\hat{\mathbf{z}}$ is $\gamma B J_z$. Calculate the susceptibility per unit volume for the atomic density n. Make a plot of the susceptibility as function of temperature (schematically, if you don't have access to a computer) (6 pt)

The solution is due on October 9.