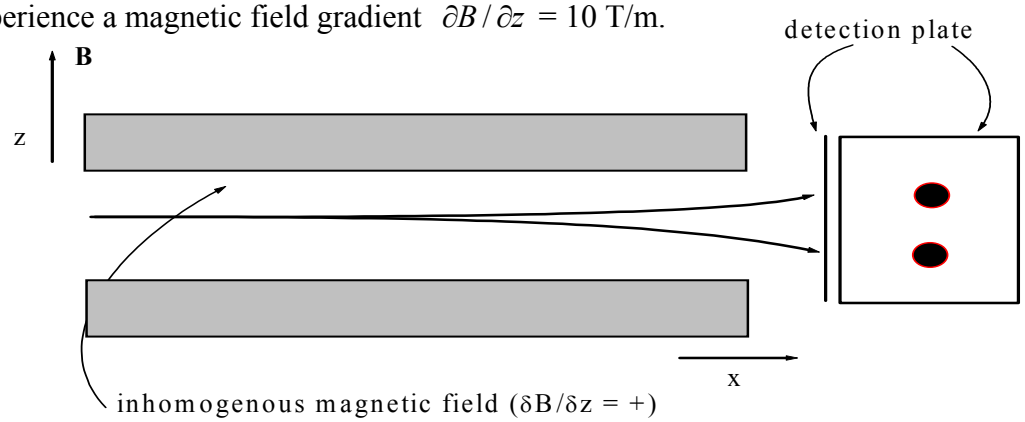
Chemistry 474b 2007

Bonus Problem Set #5 Due before the end of Study Week

1.) Illustrate the splittings in a Stern-Gerlach experiment if the beam of hydrogen atoms are in the:

a) n = 4 $\ell = 0$ state
b) n = 4 $\ell = 1$ state
c) n = 4 $\ell = 2$ state
d) n = 4 $\ell = 3$ state

2.) Consider a beam of H-atoms emitted from an oven running at temperature of T = 400 K. The beam is deflected through an inhomogeneous magnet of length = 1 m. The atoms experience a magnetic field gradient $\partial B / \partial z$ = 10 T/m.



At 400 K the atoms are in their ground state and have no orbital angular momentum. Their kinetic energy is typically $2k_BT$ where k_B is Boltzmann's constant (= 1.38 x10^{-23} JK^{-1}),

a) What is the typical atomic velocity, v_x?
b) How long in seconds does an atom experience the force in the z-direction traveling through the 1 m long magnet?
c) Calculate the transverse acceleration a_z due to the deflection force F_z.
d) Calculate, using a_z, the transverse deflection of the H-atom, z.
e) Is it reasonable that the experimental results sent to Bohr by Stern and Gerlach could fit on a postcard?

3. The appropriate H-atom wave functions for the ground state and the second excited state are: $\psi_{1s} = \psi_{1,0,0,m_s}$; $\psi_{3s} = \psi_{3,0,0,m_s}$; $\psi_{3p} = \psi_{3,1,m_\ell,m_s}$; $\psi_{3d} = \psi_{3,2,m_\ell,m_s}$

a) Evaluate the Zeeman energies for each state with n = 1 and n =3 when the hydrogen atom is placed in a static magnetic field, B.
b) Draw the energy levels and label each state.
c) Using the selection rules given in class, indicate the allowed electric dipole transitions from n =1 when he system is exposed to non-polarized light.