Physics 418, Homework Assignment
Due in Class, Wednesday, February 11, 2004

1. Using a web browser, get access to the "Table of Nuclides" from the www link on our website.
   - Make a table of all the isotopes of Carbon, listing
     - the atomic weight, A,
     - the atomic mass (amu)
     - the abundance (%) (only for stable isotopes, blank otherwise)
     - the half life with appropriate units (only for unstable isotopes)
     - the decay mode(s) - show the reaction(s) (only for unstable isotopes)
   - Do the same thing for Iron.
2. Protons with kinetic energy $\mathrm{T}_p = 10.8 MeV$ are elastically scattered from Gold nuclei ($^{197}\mathrm{Au}$).
   - Do you need relativistic kinematics for this situation?
   - What is the maximum polar angle for the final state proton?
   - What is the momentum of the proton at this angle?
   - What is the momentum of the recoil nucleus?

   Now change the incident beam particles from protons to electrons. The kinetic energy of the electrons is the same: $\mathrm{T}_e = 10.8 MeV$. They are elastically scattered from Gold nuclei.
   - Do you need relativistic kinematics for this situation?
   - What is the maximum polar angle for the final state electron?
   - What is the momentum of the electron at this angle?
   - What is the momentum of the recoil nucleus?
3. Consider the form factor for a spherically symmetric nuclear charge density.
   - Show that it can be written:
   $$F(q^2) = \frac{1}{Ze}\frac{4\pi\hbar}{q}\int_0^\infty \rho(r)\cdot r \cdot \sin\frac{qr}{\hbar} dr$$
   - What is the requirement on q such that the sine function in the integral can be safely expanded about zero?
   - Do this expansion, and show that
   $$F(q^2) = 1 - \frac{1}{6}\frac{q^2}{\hbar^2} < r^2 > + ...$$

   Here r^2 is the charge radius.
4. In the shell model of the nucleus, an example of the notation for the quantum numbers is $1s_{1/2}$, where the "principal" quantum number n=1, the orbital angular momentum quantum number $\ell = 0$ is an "s"-state, and the total angular momentum is $J = 1/2$. In the same notation, write down the highest-energy state which is just filled with a "magic number" = 82 of neutrons. Suppose we add one neutron to this nucleus to form a new isotope. Again in the same notation, what is the state of the newly added neutron? (In this problem, assume the nuclei are in their ground states.)