1. Give the formula or numerical values for :
   (a) (4%) The radius of the first Bohr orbital in hydrogen atom.
   (b) (4%) The velocity of the first Bohr orbital in hydrogen atom.
   (c) (4%) Spin of proton.
   (d) (4%) Compton wavelength of the electron.
   (e) (4%) Classical radius of electron.

2. (10 %) Suppose two photons , one with energy 6 Mev and the second with 3 Mev, approach each other along the x-axis. What is the rest energy of this system?

3. Using elementary Bohr theory,
   (a) (5%) Calculate the magnetic field at the center of a hydrogen atom where the electron is in its ground state.
   (b) (5%) We have treated the motion in the Bohr atom nonrelativistically. For what value of Z (atomic charge) will this treatment break down ? (Calculate Z for which the value of velocity would be c for n=1).

4. (10%) For what kinetic energy will a particle`s de Broglie wavelength equal its Compton wavelength ?

5. (a) (8%) Use Bohr's model to show that the energy of the transitions between two shells with principal quantum numbers n and $n'=n+1$ of a hydrogen atom is proportional to $1/n^3$ for large n.
(b) (3%) Calculate the frequency of the transition between the $n=50$ and $n'=51$ shells. Express your answer in atomic unit.
(c) (4%) Estimate the size of a hydrogen atom in these Rydberg states? Express your answer in meters.

6. (a) (5%) How many electrons can be accommodated in an electron energy level with $l=2$, where l is the orbital angular momentum quantum number? Why?
(b) (5%) Assume the electron has a spin of 3/2. How many electrons can be accommodated in an electron energy level with $l=2$?

7. (10%) An electron is confined in an atom of size of 10^{-8} cm. Estimate the minimum uncertainty in its velocity. Using this velocity to calculate the corresponding de Broglie wavelength. Simply using the above simple argument to explain why quantum mechanics is needed to describe the electron behavior.

8. (a) (6%) What is a laser? Write down **two** lasers and briefly describe them.
(b) (4%) Briefly describe the Zeeman and Stark effects.
(c) (3%) Compare the degeneracy pressures from two identical bosons and two identical fermions that are individually confined in the one-dimensional box of the same size. You should show your thoughts clearly.
(d) (2%) Show **two** experiments to indicate the existence of energy levels in atoms.