1. Werner Heisenberg, in 1932, suggested that nuclear forces
20% result from the constant exchange of heavy quanta between two nucleons. The Japanese physicist Yukawa established this fact theoretically in 1935. Make use of the uncertainty principle to estimate the mass of this heavy quanta exchanged between nucleons. The range of the nuclear force is about 1.2×10^{-13} cm.

2.
Spin flip is the transition of the spin of an electron
15% from a parallel to an antiparallel orientation, and vice versa. Such transitions can be induced by a radiofrequency signal. Calculate the frequency of a signal which would cause such a transition in a magnetic field of 1.0 weber/m^2.

3. The differential cross-section $d\sigma/d\Omega$ for the reaction
20% $p + p \rightarrow \pi^+ + d$ was first measured by Cartwright. et al. (1953), using 340-MeV incident protons. Find the pion (π^+) CMS kinetic energy.

4. A μ-meson which is 210 times as heavy as an electron
15% is captured by a proton to form a hydrogen-like atom.
   (a) What is the energy of the photon that is emitted when the μ-meson falls from the first excited state to the ground state?
   (b) What is the radius of the first Bohr orbit?
   (c) What is the velocity of the μ-meson in the nth circular Bohr orbit?

5. What are the possible states of an atom if they are
15% determined by two equivalent np electrons?

6. Explain the twin paradox.
15%