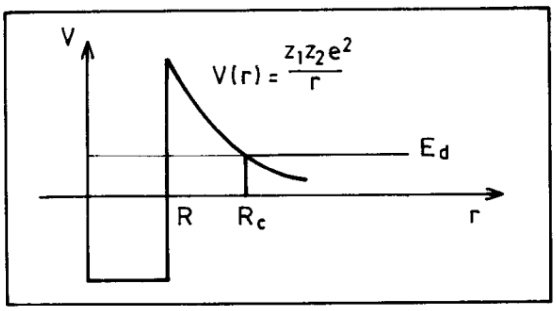
TUTORIAL:PH306

(1) The deuteron is a bound state of a proton and a neutron of total angular momentum J = 1. It is known to be principally an S(l = 0) state with a small admixture of a D(l = 2) state.
(a) Explain why a P state cannot contribute.
(b) Explain why a G state cannot contribute.

(2) The only bound two-nucleon configuration that occurs in nature is the deuteron with total angular momentum J = 1 and binding energy -2.22 MeV.
(a) From the above information alone, show that the n − p force must be spin dependent.

(3) If the nuclear force is charge independent and a neutron and a proton form a bound state, then why is there no bound state for two neutrons? What information does this provide on the nucleon-nucleon force?

(4) All of the heaviest naturally-occurring radioactive nuclei are basically unstable because of the Coulomb repulsion of their protons. The mechanism by which they decrease their size is alpha-decay. Why is alphadecay favored over other modes of disintegration (like proton-, deuteron- or triton-emission, or fission)? Discuss briefly in terms of
(a) energy release, and
(b) Coulomb barrier to be penetrated.



5) Assume a uranium nucleus breaks up spontaneously into two roughly equal parts. Estimate the reduction in electrostatic energy of the nuclei. What is the relationship of this to the total change in energy? (Assume uniform charge distribution; nuclear radius= $1.2 \times 10^{-13} A^{1/3}$ cm)

6) A Geiger counter consists of a 10 mm diameter grounded tube with a wire of 50 μm diameter at +2000 V in the center. What is the electrical field at the wire?
(a) 200 2 V/cm. (b) 150 kV/cm. (c) 1.5×10^{9} V/cm.

7) To penetrate the Coulomb barrier of a light nucleus, a proton must have a minimum energy of the order of
(a) 1 GeV. (b) 1 MeV. (c) 1 KeV.

8) (a) Calculate the electrostatic energy of a charge Q distributed uniformly throughout a sphere of radius R.
(b) Since $^{27}_{14}$Si and $^{27}_{13}$Al are “mirror nuclei”, their ground states are identical except for charge. If their mass difference is 6 MeV, estimate their radius (neglecting the proton-neutron mass difference).