1 Nuclear Physics Fall 2005 Final Exam Instructor: Prof. M. Amarian due Tuesday, December 13

1. A material is known to be an isotope of lead, although the particular isotope is not known. From such limited information, which of the following quantities can you specify:a)its atomic number, b) its neutron number, and c) its atomic mass number. Explain.

2. Two isotopes of hydrogen, ${}^{2}_{1}\mathrm{H}$ (deuterium, D) and ${}^{3}_{1}\mathrm{H}$ (tritium, T), fuse to form ${}^{4}_{2}\mathrm{He}$ and neutron. Determine the energy released by this fusion reaction.

3. Explain the difference between fission and fusion and why each process produces energy.

4. Antiprotons are created when a beam of high-energy protons strikes hydrogen target. In the laboratory system what is the minimum proton kinetic energy required for the reaction to take place?

5. At HERA, a 30 GeV electron beam collides with 820 GeV proton beam at zero crossing angle. Evaluate the total center-of-mass energy and show that a fixed-target electron accelerator would require a beam energy approximately 5 x 10^4 GeV to achieve the same total center-of-mass energy.

6. The deuteron is a bound state of two nucleons with spin-1 and positive parity. Show that it may only exist in ${}^3S_1$ and ${}^3D_1$ states of pn system.

7. The recently observed Θ^+ pentaquark is claimed to have a quark content uudd$\bar{s}$. Show which are the possible decay modes of Θ^+. Compare observed baryon decuplet with anti-decuplet and describe what is a similarity between Ω^- hyperon and Θ^+.

8. Estimate the cross-section ratio

$$R = \frac{\sigma(e^+e^- \rightarrow hadrons)}{\sigma(e^+e^- \rightarrow \mu^+\mu^-)} \tag{1}$$

at total center-of-mass energy 2.8 GeV. How would you expect R to change when energy becomes large enough to produce a top quark?

9. in 1958 Goldhaber et al. measured the helicity of the neutrino by studying electron capture in europium. Explain how is it possible.

10. From the analysis of the Z^0 line shape at LEP it was concluded that there are 3 and only 3 kinds of light neutrinos. Explain how it was deduced.