PHYSICS102 - Spring Semester 2022 - ODU

Homework Problem 11 – Due April 20

Q1

In a typical Nuclear Power Plant, nuclei of the uranium isotope with mass number 235 split into two medium-heavy nuclei plus a few extra neutrons, thereby releasing energy that can be used to heat water. If I could put the initial ^{235}U nucleus on a scale and measure its weight, and then again weigh all the final fission products (including the neutrons) together, would the total (sum of all) mass(es) of the latter be smaller or larger than the mass of the initial nucleus? Explain!

Q2

If a nucleus of ^{232}Th (Thorium, with Z=90 protons) absorbs a neutron and the resulting nucleus undergoes two successive beta decays (emitting electrons), what nucleus (Z and A!) results?

Q3

Which produces more energy, the fission of a single uranium nucleus or the fusion of a deuterium (^{2}H) nucleus with a tritium (^{3}H) nucleus? (You can find the answer in our book or you can google it). Now how would your answer change (or would it?) if instead I asked you which produces more energy – the fission of 1 gram of uranium or the fusion of 1 gram of an equal mixture of deuterium and tritium nuclei?

Q4

High-energy particle accelerators like CERN's LHC or Jefferson Lab's CEBAF routinely produce new particles in reactions where, e.g., an electron slams into a proton and out comes an electron, a proton, and another massive particle (for instance, a pion, or eta, or J/ψ…) Where does that extra mass come from? Explain.

<u>Q5</u>

What is the most important difference between a down-quark and an electron?

a) One has spin ½, and the other is a gauge boson
b) Electrons can move around freely, while quarks are bound inside nucleons and nuclei.
c) They have opposite-sign charges

Explain your choice!

<u>Q6</u>

Which of the following is a valid description of the most important, correct (and counter-intuitive) cornerstone of Einstein's Special Theory of Relativity?

1) "Everything is relative"
2) The speed of light in vacuum is always the same, as measured from any arbitrary inertial coordinate system.
3) If a clock fixed to a fast-moving inertial system, its inner workings will gum up and the clock will slow down.

Explain your choice!