**PH354 - HW9** Elementary Particles

SHOW all your works. Put the answers in a BOX NAME:_____

**1** Calculate the total binding energy of tritium ${}^{3}_{1}$H. The mass of ${}^{3}_{1}$H is 3.016049u, the mass of the proton is 1.00782u, mass of the neutron is 1.00866u. Answer in MeV.

**2** Find the binding energy per nucleon of ${}^{238}_{92}$U. The mass of ${}^{238}_{92}$U is 238.0508u, the mass of the proton is 1.00782u, mass of the neutron is 1.00866u, $c^2$=931.50 MeV/u. Answer in MeV/nucleon.

**3** How much energy is released by the following fusion reaction? Answer in Mev.

$$ {}^{1}_{1}H + {}^{2}_{1}H \rightarrow {}^{3}_{2}He + \gamma $$

The mass of ${}^{1}_{1}$H is 1.00782u, the mass of ${}^{2}_{1}$H is 2.0141u, and the mass of ${}^{3}_{2}$He is 3.01603 u

**4** Consider the two ways ${}^{235}_{92}$U can undergo fission when bombarded with a neutron. In each case, neutrons are also released. Find the number of neutrons released when:
4.1 ${}^{140}$Xe and ${}^{94}$Sr are released as fission fragments.
4.2 ${}^{132}$Sn and ${}^{101}$Mo are released as fission fragments.

**5** If the average energy released in a fission event is 208 MeV, find the total number of fission events required to provide enough energy to keep a 68.3 W light bulb burning for 1.7 hours.

**6** Examine the following processes and state for each one:
1- If it's possible to occur (according to the following conservation laws: energy, electric charge, lepton number, baryon number). If it does not occur, state which conservation law is violate.
2- Which interaction is responsible. Assume all the decays to be at rest. The electric charges of proton and electron are not indicated. A bar over indicates the antiparticle.

6.1 $p + \bar{p} \rightarrow \pi^+ + \pi^0$
6.2 $\Sigma^- \rightarrow n + \pi^-$
6.3 $\Sigma^0 \rightarrow \Lambda + \pi^0$
6.4 $e + \bar{e} \rightarrow \mu^+\mu^-$
6.5 $\mu^- \rightarrow e + \bar{\nu}_e$
6.6 $\Delta^+ \rightarrow p + \pi^0$
6.7 $e + p \rightarrow \nu_e + \pi^0$
6.8 $p \rightarrow e^+ + \gamma$
6.9 $n + \bar{n} \rightarrow \pi^+ + \pi^- + \pi^0$
6.10 $\pi^0 \rightarrow \gamma + \gamma$
6.11 $\Sigma^+ + n \rightarrow \Sigma^- + p$

**7** Name which theories have the following features:
A. The particles are classified as leptons, quark, vector (or gauge) bosons.
B. There are five versions of it which are all related to another 11 dimensional theory.
C. It is based on the idea of unifying internal and spacetime symmetries.
D. It predicts that for every fermion must exist a corresponding boson.
E. All the particles corresponds to different aspects of one fundamental entity.
F. The interactions follow from requiring invariance under internal symmetries.
G. The strong interactions is described by the use of colors.

(the same theory might be listed more than once).