Engineering Physics 6D3
Modular Course Problem Set #1
Due Saturday morning 2003 October 18

Note: Marks are as follows:
Problems 1 – 3: 5 marks each
Problems 4 – 6: 15 marks each
Total = 60 marks.

1. Assume the McMaster Nuclear Reactor operates at a power of 2 MW. How much lighter does it become each hour?

2. Is energy absorbed or released when 4 helium atoms come together to form an oxygen atom? How much (in MeV)?

3. What is the maximum energy of the antineutrino in the β-decay of a free proton?

4. What is the separation energy in MeV of the last neutron in:
   a) $^{52}Fe_{26}$
   b) $^{235}U_{92}$
   c) $^{236}U_{92}$
   d) $^{239}U_{92}$
   Compare to the average binding energy per nucleon, ~ 8 MeV.
   Is the last neutron's separation energy greater in the odd or the even isotopes of uranium?
   What is the energy brought in (relative to the nuclide's ground-sate energy) by a very slow neutron colliding with $^{235}U_{92}$? with $^{238}U_{92}$?
   If the barrier to fission is 6 MeV high, can a very slow neutron induce fission in $^{235}U_{92}$? in $^{238}U_{92}$?

5. Show how to integrate the radioactive-rate equation to obtain the law of exponential decay. Relate λ to the half-life $T_{1/2}$ of the radioactive species. Also calculate the *mean* time before decay.

6. Heavy-Water Purity

   The purity of the heavy-water moderator is extremely important in reactor operation. In order that there be no misunderstanding, we must always clearly state whether we are specifying the purity in atom percent (at %) or weight percent (w %).

   Use the table of nuclide masses to answer the following questions:

   If a certain batch of D_2O has a purity of 99.75 weight %, what is its purity in atom %? How about if the purity is 99.85 wt %?

   Derive the general correspondence formula for a D_2O purity of x wt %.