WS 2009/10

1) Binding energy – mass.

What is the decay energy in the beta-decay of the neutron ($n \rightarrow p + e + \bar{\nu}$)?
What is the decay energy in the beta-decay of tritium ($^3H$) into $^3He$?
Use the mass table.

*Masses of electron, nucleons, and some nuclei.*

| particle | Z | N | M (MeV) | M (amu) |
|---|---|---|---|---|
| *e* | 0 | 0 | 0.511 | $5.4858 \cdot 10^{-4}$ |
| *p* | 1 | 0 | 938.279 | 1.00727647 |
| *n* | 0 | 1 | 939.573 | 1.0086650 |
| $^2H$ | 1 | 1 | 1876.138 | 2.014102 |
| $^3H$ | 1 | 2 | 2809.4527 | 3.016049 |
| $^3He$ | 2 | 1 | 2809.4340 | 3.016029 |
| $^4He$ | 2 | 2 | 3728.4287 | 4.002603 |
| $^7Li$ | 3 | 4 | | 7.01600 |
| $^9Be$ | 4 | 5 | | 9.01218 |
| $^{12}C$ | 6 | 6 | | 12 (Def.) |
| $^{16}O$ | 8 | 8 | | 15.994915 |
| $^{238}U$ | 92 | 146 | | 238.0508 |

2) Relativistic – versus non-relativistic description.

Compare the procedure in calculating binding energies for electrons within an atom with the treatment of binding energies in nuclei (consider the rest masses as compared to the binding energies).

3) Lifetime – Proton stability.

a) Show that with the decay law $N=N_o \exp(-\lambda t)$ the mean life (average lifetime) is given by the inverse of the decay constant. (use the definition of the average for a given distribution, here the distribution of decay time t).

b) Within the last decades strong efforts were undertaken to determine the stability of the proton (or its limits). The probability for decay follows the radioactive decay law. Give a lower limit for the lifetime of the proton considering that within a measuring period of $\Delta t$ = 0.4 a (years) only 4 possible decays were detected. As sample take a container (50 cm x 50 cm x 50 cm) filled with water.