The nucleus

In 1932 Chadwick formally described the neutron. It was realised that the mass of an atom lay essentially in the nucleus since the mass of an electron was only $\frac{1}{1834}$ that of the proton. The nucleus was made up of protons with a mass of 1.007277 a.m.u. and a positive charge, as well as neutrons which had no charge and a mass of 1.008665 a.m.u. One atomic mass unit (a.m.u.) was fixed at 1.66×10^{-27}kg. The atom could now be described in terms of the number of protons (Z) as well as the number of nucleons (all the particles in the nucleus). The number of nucleons (A) represents the mass of the atom as a whole number. When describing an atom, Z is always subscipt and A superscript, for example, helium is $_2He^4$.

Unstable atoms tend to decay and can emit alpha (α) or beta (β) particles as well as pure energy in the form of gamma (γ) rays. An alpha particle is the nucleus of a helium atom ($_2He^4$), so when it is emitted the atomic number and proton numbers of the original element changes. When A and Z change so does the nature of the atom. A beta particle (a high energy electron, $_{-1}e^{0}$) is emitted when a neutron is broken up into a proton and electron. Physicists realized that in these transmutations lay huge sources of energy. Three transmutations are given in the table below.

Element	Uranium (U)	Thorium (Th)	Protactinium (Pa)
Atomic number (A)	238	234	234
Proton number (Z)	92	90	91
Neutron number (N)			

1 Complete the neutron number row by applying $N = A - Z$.

2 The equation for uranium decaying into thorium is $_{92}U^{238} \rightarrow {}_{90}Th^{234} + Y$.
Y represents either an alpha or beta particle which has been emitted. Complete the equation and state which particle Y is. *Note*: the subscripts and superscripts on the left hand side must match those on the right hand side.

3 Thorium decays to protactinium as $_{90}Th^{234} \rightarrow {}_{91}Pa^{234} + Y$. Follow the same procedure as in question 2 and state if Y is an alpha or beta particle.

4 Calculate the mass of the sum of the particles in the uranium (^{238}U) atom remembering that there are the same number of electrons as there are protons. Express your answer as a.m.u.

5 The mass of ^{238}U is 238.050080 a.m.u. The difference between this amount and the one calculated for the sum of the particles (in question 4) is known as the mass defect (Δm). Find out what it is.

6 The mass defect (Δm) represents the binding energy (ΔE) required for the nucleus to be formed in the first place. Calculate this by applying $\Delta E = \Delta mc^2$.
Note: don't forget to change your answer from a.m.u. to kg.

7 Many physicists feel that the final key to understanding matter will be found in the nucleus of the atom. Exotic names have been given and unusual behaviours observed as smaller and smaller particles have been discussed and then woven into the study of matter. Use text books, CD-ROMs or the Internet to find out what you can about the particles which are called baryons, leptons, hadrons and quarks.

