Nuclear Physics and Radioactivity

Equations:

Equivalence of Mass Change and Energy:

$$\Delta E(\text{inMeV}) = \Delta M(\text{in a.u.}) \cdot 931.5$$

$\Delta E/\Delta M$ are the changes in energy/mass of a reaction.

Nuclear Notation

$${}^{235}_{92}U \rightarrow^{A}_{Z} U$$

describe Uranium with 235 nucleons. (All Uranium has 92 protons so Z is redundant with U.

Radius of a Nucleus

$$R = 1.2A^{1/3}\ fm$$

Radioactive Decay:

$$\frac{\Delta N}{\Delta t} = -\lambda N$$

$$N(t) = N_0 \exp -\lambda t$$

where λ is the decay constant, N is the number of nuclei at time t and N_0 is the number of radioactive nuclei at $t = 0$.

Radioactive half-life:

$$t_{1/2} \quad = \quad \frac{\log 2}{\lambda} \quad = \quad \frac{.693}{\lambda}$$

Radioactive Dose Units:

$$1.0R(roentgen) = 2.58 \times 10^{-4}(C/kg), \text{a measure of ionization per mass}$$

$$1.0Gy(gray) = 1.0(J/kg), \text{a measure of energy deposited per mass}$$

$$1.0rad = .01Gy, \text{a measure of energy deposited per mass}$$

$$\text{Dose(in}rems) = RBE \text{ Dose(in}rads)$$

RBE=biological effectiveness, see text, page 1009.

Assorted Facts:

1. The strong force attracts nucleons together. It attracts protons to neutrons more than protons to protons or neutrons to neutrons.
2. Nuclei prefer to have Z (proton number) roughly equal N (neutron number), although for heavy nuclei, more neutrons are better due to electrostatic energy.
3. γ decay involves the emission of a high energy photon (γ). It does not change N or Z.
4. β decay involves the emission of an electron or anti-electron. It changes Z and N by one unit but does not change A ($A = Z + N$).
5. Particle emission changes Z and N and involves quantum mechanical barrier penetration. Examples of such are α emission and fission.
6. An α particle is a ${}^4Henucleus.$Very heavy nuclei become unstable due to the electrostatic repulsion of the protons.