Problem Solving Class: Van Quark tot Biomaterie

Problem Set 11: Radioactivity
Hand-in on paper Monday 24 November (before 12:00 h)
in Mailbox Madhu Talluri (Mailboxes W&N building)
Hand-in digitally, email to: m.t.talluri@vu.nl;
All documents in a single file [file: YourName-WC-P3]
All answers in English

1) Kinetic energy in α-decay

Calculate the kinetic energy of an α-particle from the reaction:

$$^{210}_{84}Po \rightarrow ^{206}_{82}Pb + \alpha$$

Mass ^{210}Po=209.984188 u; Mass ^{206}Pb=205.974465 u. Take into account the recoil of the daughter nucleus. A non-relativistic calculation suffices.

Calculate the kinetic energy distribution in a bit more general terms. Show that the nucleus carries away a fraction of

$$\frac{1}{1+\frac{1}{4}A_D}$$

Of the total energy available, where A_D is the mass of the daughter nucleus. [Hint use conservation laws for energy and momentum in a non-relativistic approach].

2) ^{14}C - Carbon dating

A sample of pure carbon weighing 385 gram contains 1.3 x 10^{12} atoms of ^{14}C. Note that the half-life of ^{14}C is 5730 years, and that for finding the number of atoms in the sample you may use the approximation that the amount of ^{13}C and ^{14}C is very small.

A) Calculate how many integrations occur per second

An ancient wooden club is found that contains 85 gram of carbon and has an activity of 7.0 decays per second. It is given that in living trees the ratio of ^{14}C/^{12}C is about 1.3 x 10^{-12}.

B) Determine the age of the wooden club.

3) Very long-lived isotopes

Some radioactive isotopes have half-lives larger than the age of the universe (like the Tellurium isotopes discussed).
Suppose we find an asteroid that contains 15000 kg of $^{152}Gd_{54}$ and we detect an activity of 1 decay/second.
What is then the half-life of this Gd-isotope (in years) ?