

April 11, 2008

Quiz 7 - PHY244 (Modern Physics)

Print (Hugely) Last Name:

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First name:

Solution

Giving or receiving aid is cause for dismissal from the university.

$$m_e c^2 = 511000 \text{ eV}, c = 3 \times 10^8 \text{ m/s}, hc = 1240 \text{ nm}\cdot\text{eV}, 1 \text{ u} = 931.5 \text{ MeV}/c^2.$$

$$dN/dt = -rN, N(t) = N_0 e^{-rt}, \tau = 1/r, t_{1/2} = \tau \ln 2; \quad {}^A_Z X_N : A = N + Z$$

The tiny fraction f of ${}^{14}_6\text{C}$ to all C in the atmosphere has remained roughly constant over many thousands of years, in spite of the fact that ${}^{14}_6\text{C}$ decays with a half-life $t_{1/2} = 5730$ yr. This is because ${}^{14}_6\text{C}$ is produced continually in collisions between cosmic rays and nitrogen nuclei in the atmosphere.

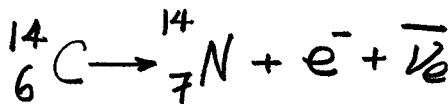
Determine the maximum kinetic energy of the β^- ray from the ${}^{14}_6\text{C}$ decay. We know the atomic masses:

$$m({}^{14}_6\text{C}) = 14.003242 \text{ u},$$

$$m({}^{13}_6\text{C}) = 13.003355 \text{ u},$$

$$m({}^{14}_8\text{O}) = 14.008595 \text{ u},$$

$$m({}^{14}_7\text{N}) = 14.003074 \text{ u}.$$



$$m({}^{14}_6\text{C}) - m({}^{14}_7\text{N}) = 14.003242 \text{ u} - 14.003074 \text{ u}$$

$$= 0.000168 \text{ u} = 0.1565 \text{ MeV}/c^2$$

$$(K.E.)_{\text{max}} = 0.1565 \text{ MeV}$$

Given that each gram of carbon from a living tree has a ${}^{14}_6\text{C}$ activity of 15 disintegration/min, determine the tiny fraction f .

$$15 / \text{min} = f \frac{1 \text{ gm}}{12 \text{ gm/mole}} \times (6.023 \times 10^{23} / \text{mole}) \times \frac{\ln 2}{5730 \times 365 \times 24 \times 60 \text{ min}}$$

$$= 11.5 \times 10^{12} f / \text{min}.$$

$$f = 1.3 \times 10^{-12}$$

A 5 gram charcoal sample from an ancient fire pit has a ${}^{14}_6\text{C}$ activity of 30 disintegration/min. How old is the charcoal sample?

1 gm of charcoal sample gives 6 disint/min

$$\frac{6}{15} = \left(\frac{1}{2}\right)^{t/t_{1/2}}$$

$$\frac{t}{t_{1/2}} = \frac{\ln 6/15}{\ln(0.5)} = 1.32$$

$$t = 7575 \text{ years}$$