Physics 112: General Physics II: Electricity, Magnetism, and Optics
Beta Decay

Problem 1: (20 pts.) Radioactive $^{14}_{6}\mathrm{C}$ decays by beta decay.

a. (5 pts.) What is the resulting nucleus?

b. (15 pts.) The mass of $^{14}_{6}\mathrm{C}$ is $14.003\,242\,\mathrm{u}$, and the mass of the resulting nucleus is $14.003\,074\,\mathrm{u}$. You may ignore the mass of the anti-neutrino. (The electron is already accounted for in the atomic masses.) How much energy is released in this reaction?

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a. (5 pts.) What is the resulting nucleus?

In beta decay, a neutron is replaced by a proton, so the resulting nucleus has 7 protons, which is Nitrogen.

$$ {}^{14}_{6}\mathrm{C} \rightarrow {}^{14}_{7}\mathrm{N} + \mathrm{e}^{-} + \bar{\nu}_e $$

b. (15 pts.) The mass of ${}^{14}_{6}\mathrm{C}$ is 14.003 242 u, and the mass of the resulting nucleus is 14.003 074 u. You may ignore the mass of the anti-neutrino. (The electron is already accounted for in the atomic masses.) How much energy is released in this reaction?

$$
\begin{aligned}
m_C &= 14.003\,242\,\mathrm{u} \\
m_N &= 14.003\,074\,\mathrm{u} \\
m_C - m_N &= \ \ 0.000\,168\,\mathrm{u}
\end{aligned}
$$

The energy released is thus

$$
\begin{aligned}
\Delta E &= (\Delta m)c^2 = (0.000\,168\,\mathrm{u}) \times c^2 \\
\Delta E &= (0.000168) \times (1\,\mathrm{u}) \times c^2 \\
\Delta E &= (0.000\,168) \times (931.5\,\mathrm{MeV}) = 0.156\,\mathrm{MeV}
\end{aligned}
$$