

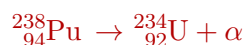
Physics 112: General Physics II: Electricity, Magnetism, and Optics
Radioactive Decay Power

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The original (parent) nucleus is Plutonium-238: $^{238}_{94}\text{Pu}$, with $Z = 94$ and $A = 238$. If it decays by alpha decay, then it decays to the element with $Z = 92$ and $A = 234$, which is Uranium-234: $^{234}_{92}\text{U}$. The reaction is thus



The energy per decay arises from the mass difference:

$$\begin{aligned}\Delta m &= m_{\text{Pu}} - (m_{\text{U}} + m_{\alpha}) \\ \Delta m &= 238.049\,56\text{ u} - (234.040\,952\text{ u} + 4.002\,603\text{ u}) \\ \Delta m &= 238.049\,56\text{ u} \\ &\quad - 238.043\,555\text{ u} \\ \Delta m &= 0.006\,01\text{ u} \\ \Delta E &= (\Delta m)c^2 = (0.006\,01\text{ u})c^2 \\ \Delta E &= 5.59\text{ MeV}\end{aligned}$$

If the activity is $R = 6.30 \times 10^{15}$ Bq, then the power (*i.e.* Joules per second) is

$$\begin{aligned}P &= R \times \Delta E \\ P &= (6.30 \times 10^{15}\text{ Bq}) \times (5.59\text{ MeV/decay}) \\ P &= (6.30 \times 10^{15}\text{ decays/s}) \times (5.59\text{ MeV/decay}) \\ P &= (3.52 \times 10^{16}\text{ MeV/s}) \times \left(\frac{1 \times 10^6\text{ eV}}{1\text{ MeV}} \times \frac{1.602 \times 10^{-19}\text{ J}}{1\text{ eV}} \right) \\ P &= \boxed{5650\text{ W}}\end{aligned}$$