

19. If R is the decay rate then the power output is $P = RQ$, where Q is the energy produced by each alpha decay. Now $R = \lambda N = N \ln 2 / T_{1/2}$, where λ is the disintegration constant and $T_{1/2}$ is the half-life. The relationship $\lambda = (\ln 2) / T_{1/2}$ is used. If M is the total mass of material and m is the mass of a single ^{238}Pu nucleus, then

$$N = \frac{M}{m} = \frac{1.00 \text{ kg}}{(238 \text{ u})(1.661 \times 10^{-27} \text{ kg/u})} = 2.53 \times 10^{24} .$$

Thus,

$$P = \frac{NQ \ln 2}{T_{1/2}} = \frac{(2.53 \times 10^{24})(5.50 \times 10^6 \text{ eV})(1.60 \times 10^{-19} \text{ J/eV})(\ln 2)}{(87.7 \text{ y})(3.156 \times 10^7 \text{ s/y})} = 558 \text{ W} .$$