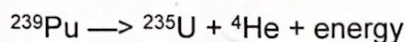


Quiz 31.1C

An experimental nuclear reactor is being tested that will power a small city. In a given day, the average resident of the city uses 12 kW-hr of energy, and there were 45,000 residents. The reactor contains 2.5 kg of Plutonium-239, which will be used in the fission reaction:



The masses of each component of the nuclear reaction are:

$$m(^{239}\text{Pu}) = 239.052156 \text{ amu}$$

$$m(^{235}\text{U}) = 235.043923 \text{ amu}$$

$$m(^4\text{He}) = 4.002602 \text{ amu}$$

Determine (a) how much energy (in MeV) is produced by each nuclear reaction and (b) how many days in total will the Plutonium supply be able to provide the energy the city needs, assuming the reaction can be controlled in such a way that the rate of energy generation is constant.

$$a) \Delta m = .005631 \text{ u}$$

$$E = (.005631)(931.5) = \boxed{5.245 \text{ MeV}} = 8.4 \times 10^{-13} \text{ J}$$

$$b) E_{\text{DAY}} = \frac{12 \text{ kW}\cdot\text{hr}}{\text{person}} \cdot \frac{3.6 \times 10^6 \text{ J}}{\text{kW}\cdot\text{hr}} \cdot 2100 \text{ persons}$$

$$= \underline{9.072 \times 10^{10} \text{ J}} \text{ in one day}$$

$$E_{\text{TOT}} = \frac{5.245 \text{ MeV}}{\text{reac}} \cdot \frac{1.6 \times 10^{-13} \text{ J}}{\text{MeV}} \cdot N_{\text{reac}}$$

$$N_{\text{reac}} = \frac{m_{\text{TOT}}}{m_{\text{Pu}}} = \frac{2.5}{239 \times (1.66 \times 10^{-27} \text{ kg/u})} = 6.3 \times 10^{24}$$

$$E_{\text{TOT}} = 5.29 \times 10^{12}$$

$$N_{\text{DAYS}} = \frac{E_{\text{TOT}}}{E_{\text{DAY}}} = \frac{5.29 \times 10^{12}}{9.072 \times 10^{10}} = \boxed{58 \text{ days}}$$

Alt!

$$N_{\text{reac}} = \frac{E_{\text{DAY}}}{E_{\text{reac}}} = 1.05 \times 10^{23}$$

$$\text{per day}$$

$$m_{\text{day}} = (N_{\text{reac per day}}) m_{\text{Pu}} = .0428$$

$$N_{\text{day}} = \frac{m_{\text{TOT}}}{m_{\text{DAY}}} = 58 \text{ days}$$