878.

Problem 55.32 (RHK)

The natural fission reactor is estimated to have generated 15 gigawatt-years *of energy during its lifetime*. (a) *If the reactor has lasted for* 200,000 y, *we have to calculate the average power level at which it operated*. (b) *We have to find the amount of* $^{235}\mathrm{U}$ *that it consumed during its lifetime*.

Solution:

(a)

A natural fission reactor is estimated to have generated 15 gigawatt-years of energy during its lifetime. The reactor has lasted for 200,000 y.

Therefore, the average power level at which it operated was

$$P = \frac{15\times10^{9}\ \text{watt y}}{200{,}000\ \text{y}} = 7.5\times10^{4}\ \text{watt} = 75\ \text{kW}.$$

(b)

We take that average yield of energy per fission of $^{235}\mathrm{U}$ is 200 MeV. Therefore, the total numbers of fissions that would have released 15 gigawatt-years of energy will be

$$N = \frac{15\times10^{9}\ \mathrm{J\ s^{-1}}\times3.156\times10^{7}\ \mathrm{s}}{1.6\times10^{-13}\ \mathrm{J\ MeV^{-1}}\times200\ \mathrm{MeV}}$$
$$= 14.79\times10^{27}.$$

The amount of $^{235}\mathrm{U}$ that will contain 14.79×10^{27} atoms of $^{235}\mathrm{U}$ will be

$$m = \frac{235\times14.79\times10^{27}\ \mathrm{g}}{6.02\times10^{23}}$$
$$= 5.77\times10^{3}\ \mathrm{kg}.$$