A radioactive nucleus has an average lifetime of only 100 minutes. If you started with a million such nuclei, how many would be left after 100 min? What is the half-life of this nucleus?

Answer: the number remaining would be 3.7×10^5 after 100 min. The half-life wouild be 69.3 min.

In a nuclear reaction, $a + A \rightarrow B + b$, the masses of initial and final states are 14070 and 14080 MeV respectively. What is the minimum lab kinetic energy of a that would allow this reaction to take place? Assume M_a/M_A is 0.1.

Answer: 11 MeV.

A nuclear process that is important astrophysically (in red giant stars) is the following. What goes in the blank?

$$^4\mathrm{He} + ^{12}\mathrm{C} \rightarrow \underline{\hspace{2cm}} + \gamma.$$

Solutions:

• $N(t) = N(0)\exp(-t/\tau)$. So after a time $t = \tau =$ 100 min, if $N(0) = 10^6$, then $N = 10^6\exp(-1) = 3.7 \times 10^5$. The half-life is $T_{1/2} = 0.693\tau = 69.3$ min.

• Suppose the total mass for colliding nuclei a and A is 14070 MeV and the total mass for resulting nuclei b and B is 14080 MeV. Also suppose $M_a/M_A = 0.1$. The Q-value for the process is thus -10 MeV, which means that in the center of mass system of the collison there has to be a kinetic energy of at least 10 MeV in order to create b and B at rest. If the process is a "fixed-target" arrangement with A at rest and a beam of a from an accelerator, then the minimum laboratory KE for a is $KE_a = (1+0.1)10$ MeV $= 11$ MeV.

•The total number of protons involved in the process is $2 + 6 = 8$, and the total number of neutrons is $2 + 6 = 8$, so if there is just one resulting nucleus, it must have $Z = 8$ and $A = 16$, and so must be

$$^{16}\mathrm{O}.$$