

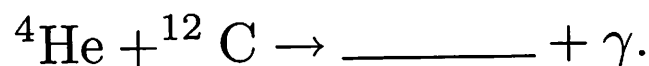
A radioactive nucleus has an average lifetime of only 100 minutes. If you started with a million such nuclei, how many would be left after 100 min? What is the half-life of this nucleus?

Answer: the number remaining would be  $3.7 \times 10^5$  after 100 min. The half-life would 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?



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 collision 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  $KE_a = (1 + 0.1)10 \text{ MeV} = 11 \text{ MeV}$ .

• 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

