867.

Problem 55.16 (RHK)

In a particular fission event of $^{235}\mathrm{U}$ *by slow neutrons, it happens that no neutron is emitted and that one of the primary fission fragments is* $^{83}\mathrm{Ge}$. *We have to answer the following*: (a) *What is the other fragment*? (b) *How is the disintegration energy* $Q = 170\ \mathrm{MeV}$ *split between the two fragments*? (c) *We have to calculate the initial speed of each fragment.*

Solution:

(a)

In a particular fission event of $^{235}\mathrm{U}$ by slow neutrons, it happens that no neutron is emitted and that one of the primary fission fragments is $^{83}\mathrm{Ge}$. As the atomic number of $^{235}\mathrm{U}$ is 92 and one thermal neutron is absorbed the total mass number of the compound nucleus that disintegrates by fission will be 236. The atomic number of germanium, $^{83}\mathrm{Ge}$, is 32, therefore, the other fission fragment has to be neodymium, $^{153}\mathrm{Nd}$.

(b)

We assume that the compound nucleus ^{236}U decays at rest. From conservation of momentum the fission energy Q will be divided as

$$KE_{^{83}\text{Ge}} = \frac{m_{^{153}\text{Nd}}Q}{m_{^{83}\text{Ge}} + m_{^{153}\text{Nd}}} = \frac{153Q}{83+153}$$

$$= \frac{153}{236} \times 170 \text{ MeV}$$

$$= 110.2 \text{ MeV.}$$

And the kinetic energy of the ^{153}Nd nuclide will be

$$KE_{^{153}\text{Nd}} = \frac{m_{^{83}\text{Ge}}Q}{m_{^{83}\text{Ge}} + m_{^{153}\text{Nd}}} = \frac{83Q}{83+153}$$

$$= \frac{83}{236} \times 170 \text{ MeV}$$

$$= 59.8 \text{ MeV.}$$

(c)

The initial speed of the ^{83}Ge nuclide will be

$$v_{^{83}\text{Ge}} = \sqrt{\frac{2KE_{^{83}\text{Ge}}}{m_{^{83}\text{Ge}}}} = \left(\frac{2\times110.2\times1.6\times10^{-13}}{83\times10^{-3}/6.02\times10^{23}}\right)^{1/2} \text{ m s}^{-1}$$

$$= 15.99 \times 10^{6} \text{ m s}^{-1}.$$

And, the initial speed of the ^{153}Nd nuclide will be

$$v_{^{153}\mathrm{Nd}} = \sqrt{\frac{2KE_{^{153}\mathrm{Nd}}}{m_{^{153}\mathrm{Nd}}}} = \left(\frac{2 \times 59.8 \times 1.6 \times 10^{-13}}{153 \times 10^{-3} / 6.02 \times 10^{23}} \right)^{1/2} \ \mathrm{m\ s^{-1}}$$

$$= 8.68 \times 10^{6} \ \mathrm{m\ s^{-1}}.$$