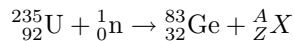


11. (a) If X represents the unknown fragment, then the reaction can be written



where  $A$  is the mass number and  $Z$  is the atomic number of the fragment. Conservation of charge yields  $92+0 = 32+Z$ , so  $Z = 60$ . Conservation of mass number yields  $235+1 = 83+A$ , so  $A = 153$ . Looking in Appendix F or G for nuclides with  $Z = 60$ , we find that the unknown fragment is  ${}_{60}^{153}\text{Nd}$ .

- (b) We neglect the small kinetic energy and momentum carried by the neutron that triggers the fission event. Then,  $Q = K_{\text{Ge}} + K_{\text{Nd}}$ , where  $K_{\text{Ge}}$  is the kinetic energy of the germanium nucleus and  $K_{\text{Nd}}$  is the kinetic energy of the neodymium nucleus. Conservation of momentum yields  $\vec{p}_{\text{Ge}} + \vec{p}_{\text{Nd}} = 0$ . Now, we can write the classical formula for kinetic energy in terms of the magnitude of the momentum vector:

$$K = \frac{1}{2}mv^2 = \frac{p^2}{2m}$$

which implies that  $K_{\text{Nd}} = (m_{\text{Ge}}/m_{\text{Nd}})K_{\text{Ge}}$ . Thus, the energy equation becomes

$$Q = K_{\text{Ge}} + \frac{M_{\text{Ge}}}{M_{\text{Nd}}}K_{\text{Ge}} = \frac{M_{\text{Nd}} + M_{\text{Ge}}}{M_{\text{Nd}}}K_{\text{Ge}}$$

and

$$K_{\text{Ge}} = \frac{M_{\text{Nd}}}{M_{\text{Nd}} + M_{\text{Ge}}}Q = \frac{153 \text{ u}}{153 \text{ u} + 83 \text{ u}}(170 \text{ MeV}) = 110 \text{ MeV} .$$

Similarly,

$$K_{\text{Nd}} = \frac{M_{\text{Ge}}}{M_{\text{Nd}} + M_{\text{Ge}}}Q = \frac{83 \text{ u}}{153 \text{ u} + 83 \text{ u}}(170 \text{ MeV}) = 60 \text{ MeV} .$$

- (c) The initial speed of the germanium nucleus is

$$v_{\text{Ge}} = \sqrt{\frac{2K_{\text{Ge}}}{M_{\text{Ge}}}} = \sqrt{\frac{2(110 \times 10^6 \text{ eV})(1.60 \times 10^{-19} \text{ J/eV})}{(83 \text{ u})(1.661 \times 10^{-27} \text{ kg/u})}} = 1.60 \times 10^7 \text{ m/s} .$$

The initial speed of the neodymium nucleus is

$$v_{\text{Nd}} = \sqrt{\frac{2K_{\text{Nd}}}{M_{\text{Nd}}}} = \sqrt{\frac{2(60 \times 10^6 \text{ eV})(1.60 \times 10^{-19} \text{ J/eV})}{(153 \text{ u})(1.661 \times 10^{-27} \text{ kg/u})}} = 8.69 \times 10^6 \text{ m/s} .$$