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

$$^{235}_{92}\mathrm{U} + ^{1}_{0}\mathrm{n} \rightarrow ^{83}_{32}\mathrm{Ge} + ^{A}_{Z}X$$

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 $^{153}_{60}\mathrm{Nd}$.

(b) We neglect the small kinetic energy and momentum carried by the neutron that triggers the fission event. Then, $Q = K_{\mathrm{Ge}} + K_{\mathrm{Nd}}$, where $K_{\mathrm{Ge}}$ is the kinetic energy of the germanium nucleus and $K_{\mathrm{Nd}}$ is the kinetic energy of the neodymium nucleus. Conservation of momentum yields $\vec{p}_{\mathrm{Ge}} + \vec{p}_{\mathrm{Nd}} = 0$. 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 $K_{\mathrm{Nd}} = (m_{\mathrm{Ge}}/m_{\mathrm{Nd}})K_{\mathrm{Ge}}$. Thus, the energy equation becomes

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

and

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

Similarly,

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

(c) The initial speed of the germanium nucleus is

$$v_{\mathrm{Ge}} = \sqrt{\frac{2K_{\mathrm{Ge}}}{M_{\mathrm{Ge}}}} = \sqrt{\frac{2(110\times10^6\,\mathrm{eV})(1.60\times10^{-19}\,\mathrm{J/eV})}{(83\,\mathrm{u})(1.661\times10^{-27}\,\mathrm{kg/u})}} = 1.60\times10^7\ \mathrm{m/s}\ .$$

The initial speed of the neodymium nucleus is

$$v_{\mathrm{Nd}} = \sqrt{\frac{2K_{\mathrm{Nd}}}{M_{\mathrm{Nd}}}} = \sqrt{\frac{2(60\times10^6\,\mathrm{eV})(1.60\times10^{-19}\,\mathrm{J/eV})}{(153\,\mathrm{u})(1.661\times10^{-27}\,\mathrm{kg/u})}} = 8.69\times10^6\ \mathrm{m/s}\ .$$