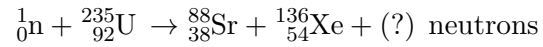


Physics 112: General Physics II: Electricity, Magnetism, and Optics
Nuclear Fission

Problem 1: Complete the following fission reaction and determine the amount of energy it releases:



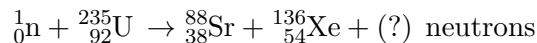
First, tabulate some data from Appendix C (or a similar source):

Neutron	${}_0^1\text{n}$	1.008 665 u
Uranium-235	${}_{92}^{235}\text{U}$	235.043 930 u
Strontium-88	${}_{38}^{88}\text{Sr}$	87.905 612 u
Xenon-136	${}_{54}^{136}\text{Xe}$	135.907 219 u

- a. How many neutrons are released?
- b. How much energy is released by this reaction?

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a. How many neutrons are released?

On the left hand side of the reaction, the number of neutrons is

$$N_{\text{initial}} = 1 + (235 - 92) = 144$$

On the right hand side, the final number of neutrons listed is

$$N_{\text{final}} = (88 - 38) + (136 - 54) = 132$$

Therefore the number of extra neutrons is $144 - 132 = 12$. The reaction started with 1 incoming neutron, and generates 12 outgoing neutrons, each of which might initiate its own reaction. This leads to a “chain reaction” where the number of fission events increases rapidly.

b. How much energy is released by this reaction?

The initial and final masses are

$$\begin{aligned} m_i &= m_n + m_{235\text{U}} = 1.008\,665\text{ u} + 235.043\,930\text{ u} = 236.052\,595\text{ u} \\ m_f &= m_{88\text{Sr}} + m_{136\text{Xe}} + 12 \times m_n \\ &= 87.905\,612\text{ u} + 135.907\,219\text{ u} + 12 \times 1.008\,665\text{ u} = 235.916\,810\text{ u} \end{aligned}$$

The mass difference Δm (and corresponding energy released Δmc^2) are

$$\begin{aligned} \Delta m &= m_i - m_f = 236.052\,595\text{ u} - 235.916\,810\text{ u} = 0.135\,785\text{ u} \\ \Delta E &= (\Delta m)c^2 = (0.135\,785\text{ u}) \times \left(\frac{931.5\text{ MeV}}{(1\text{ u})c^2} \right) = 126\text{ MeV} \end{aligned}$$