

Cross section and Bomb design

Axis-German physicists' error We are going to repeat the homework problem 17.52, but assuming a much smaller fission cross section $\sigma = 0.05$ barns. Such a small value might be an underestimation by Axis-German physicists who then predicted an unachievably huge nuclear bomb than actually required.

$$N = N_{inc} \frac{\sigma}{A} N_{tar} = N_{inc} \sigma \left(\frac{N_{tar}}{V} \right) L, \text{ where the volume } V = AL$$

To sustain the chain reaction, it is required that $f \equiv N/N_{inc} = 2/5$ or larger.

$$\left(\frac{N_{tar}}{V} \right) = 19 \frac{\text{gm}}{\text{cm}^3} \times \frac{6.02 \times 10^{23} \frac{1}{\text{mole}}}{235 \frac{\text{gm}}{\text{mole}}} = 4.87 \times 10^{22} \text{cm}^{-3} .$$

$$\frac{N}{N_{inc}} = \sigma \left(\frac{N_{tar}}{V} \right) L = (0.05 \times 10^{-24} \text{ cm}^2)(4.87 \times 10^{22} \text{cm}^{-3})L$$

$$L = \frac{N/N_{inc}}{\sigma(N_{tar}/V)} \approx \frac{\frac{2}{5}}{0.05 \times 4.87 \times 10^{-2}} \text{ cm} \approx 164 \text{ cm}$$

The thickness required to sustain the chain reaction is unachievably large because of the wrongly chosen small value of σ . Can you reevaluate the case for an more appropriate value as given in the book.