

(6.13) Calculate the half-life for α -decay of ^{147}Sm assuming that Q_α is 2.314 MeV. Compare the result with the measured half-life and compute the hindrance factor.

$$Q := 2.314$$

$$A := 147$$

$$Z := 62$$

$$q_e := 1.60211773 \cdot 10^{-19} \cdot \text{coul}$$

$$Q_\alpha := Q \cdot 10^6 \cdot 1.60211773 \cdot 10^{-19} \cdot \text{joule}$$

$$\epsilon_0 := 8.8541878 \cdot 10^{-12} \cdot \frac{\text{coul}}{\text{volt} \cdot \text{m}}$$

$$h := 6.626076 \cdot 10^{-34} \cdot \text{joule} \cdot \text{sec}$$

$$Z_\alpha := 2$$

$$A_\alpha := 4$$

$$Z_1 := Z - Z_\alpha$$

$$r_0 := 1.30 \cdot 10^{-15} \cdot \text{m}$$

$$r_\alpha := 1.20 \cdot 10^{-15} \cdot \text{m}$$

$$A_1 := A - A_\alpha$$

$$R_{nucl} := r_0 A_1^{\frac{1}{3}} + r_\alpha$$

$$R_{nucl} = 7.998 \cdot 10^{-15} \cdot \text{m}$$

$$u_n := 1.660540 \cdot 10^{-27} \cdot \text{kg}$$

$$u := \sqrt{\frac{4 \cdot \pi \cdot \epsilon_0 \cdot Q_\alpha \cdot R_{nucl}}{Z_1 \cdot Z_\alpha \cdot q_e^2}}$$

$$u = 0.327$$

$$\mu := \frac{A_\alpha \cdot A_1}{A_\alpha + A_1} \cdot u_n$$

$$\mu = 6.461 \cdot 10^{-27} \cdot \text{kg}$$

$$\lambda := \frac{h}{2 \cdot \mu \cdot R_{nucl}^2} \cdot \exp \left[\frac{-\sqrt{2 \cdot \mu \cdot Z_1 \cdot Z_\alpha \cdot q_e^2} \cdot (\text{acos}(u) - u \cdot \sqrt{1 - u^2})}{\epsilon_0 \cdot h \cdot \sqrt{Q_\alpha}} \right]$$

$$\lambda = 2.479 \cdot 10^{-19} \cdot \text{sec}^{-1}$$

$$t_{half} := \frac{\ln(2)}{\lambda}$$

$$t_{half} = 8.861 \cdot 10^{10} \cdot \text{yr}$$

$$t_{half.exp} := 1.06 \cdot 10^{11} \cdot \text{yr}$$

$$f_{hindrance} := \frac{t_{half.exp}}{t_{half}}$$

See § 6.7.3.

$$f_{hindrance} = 1.196$$