

(15.7) A tumor has the weight of 80 g and we wish to destroy 20% of the cells by irradiating with 180 MeV protons with such penetration that half of the energy is deposited in the tumor. The particle beam is 5 μ A. For what time must the irradiation be? A cell of weight 10^{-9} g is assumed to be killed on the absorption of 200 keV and no cell is assumed to be killed twice.

$$q_e := 1.6021773 \cdot 10^{-19} \cdot \text{coul}$$

$$\mu\text{sec} := 10^{-6} \cdot \text{sec}$$

$$eV := 1.6021773 \cdot 10^{-19} \cdot \text{joule}$$

$$\text{keV} := 10^3 \cdot eV$$

$$\text{MeV} := 10^3 \cdot \text{keV}$$

$$m_{\text{tumor}} := 80 \cdot \text{gm}$$

$$m_{\text{cell}} := 10^{-9} \cdot \text{gm}$$

$$\text{Fraction} := 20 \cdot \%$$

$$I_{\text{beam}} := 5 \cdot \mu\text{A}$$

$$E_{\text{beam}} := 180 \cdot 10^6 \cdot eV$$

$$E_{\text{kill}} := 200 \cdot \text{keV}$$

$$\phi := \frac{I_{\text{beam}}}{q_e}$$

$$P_{\text{beam}} := \phi \cdot E_{\text{beam}}$$

$$P_{\text{beam}} = 900 \cdot \text{watt}$$

$$Q_{\text{kill}} := \frac{m_{\text{tumor}} \cdot \text{Fraction}}{m_{\text{cell}}} \cdot E_{\text{kill}}$$

$$t_{\text{irr}} := \frac{Q_{\text{kill}}}{0.5 \cdot P_{\text{beam}}}$$

$$t_{\text{irr}} = 1.139 \cdot 10^{-6} \cdot \text{sec}$$

$$\text{or } t_{\text{irr}} = 1.139 \cdot \mu\text{sec}$$