(18.7) 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 μA. 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.

Data, constants, and units:

$q_e := 1.6021773 \cdot 10^{-19} \cdot coul$ $\quad \mu sec := 10^{-6} \cdot sec$

$eV := 1.6021773 \cdot 10^{-19} \cdot joule$ $\quad keV := 10^{3} \cdot eV$ $\quad MeV := 10^{3} \cdot keV$

Data from the text:

$m_{tumor} := 80 \cdot gm$ $\quad m_{cell} := 10^{-9} \cdot gm$ $\quad Fraction := 20 \cdot \%$

$I_{beam} := 5 \cdot \mu A$ $\quad E_{beam} := 180 \cdot 10^{6} \cdot eV$ $\quad E_{kill} := 200 \cdot keV$

Calculations:

$$\phi := \frac{I_{beam}}{q_e} \qquad P_{beam} := \phi \cdot E_{beam} \qquad P_{beam} = 900 \cdot watt$$

$$Q_{kill} := \frac{m_{tumor} \cdot Fraction}{m_{cell}} \cdot E_{kill} \qquad t_{irr} := \frac{Q_{kill}}{0.5 \cdot P_{beam}} \qquad t_{irr} = 1.139 \cdot 10^{-6} \cdot \text{sec}$$

or

$$t_{irr} = 1.14 \cdot \mu sec$$