(7.1) How many ion pairs are produced in 10 m of air of STP by one (a) 5 MeV α-particle, (b) 1 MeV β-particle and (c) 1 MeV γ-quantum (μ_m(air) = μ_m(water))?

First we need to define the electron volt and MeV as:

$eV := 1.60217733 \cdot 10^{-19} \cdot joule$ $\qquad$ $MeV := 10^{6} \cdot eV$

The ionization energy, eV/ion pair, is taken from Table 7.1: $\qquad w := 34 \cdot eV$

(a) The range of a 5 MeV α-particle is << 10 m, hence all energy will be used for ionization:

$E_{\alpha} := 5 \cdot MeV$ $\qquad$ Hence $\qquad n := \frac{E_{\alpha}}{w}$ $\qquad n = 1.471 \cdot 10^{5}$ $\qquad$ ion pars

(b) The range of a 1 MeV β-particle is < 10 m, hence all energy will be used for ionization:

$E_{\beta} := 1 \cdot MeV$ $\qquad$ Hence $\qquad n := \frac{E_{\beta}}{w}$ $\qquad n = 2.941 \cdot 10^{4}$ $\qquad$ ion pairs

(c) The γ passes 10 m of air, hence only part of the energy will be deposited and form ion pairs. The value for μ_m(water) can be read from Fig. 6.17:

$E\gamma := 1 \cdot MeV$ $\qquad \mu_{mair} := 0.026 \cdot \frac{cm^2}{gm}$ $\qquad \rho_{air} := 1.293 \cdot 10^{-3} \cdot \frac{gm}{cm^3}$

$\mu_{air} := \mu_{mair} \cdot \rho_{air}$ $\qquad$ Linear absorption coefficient

$x := 10 \cdot m$ $\qquad$ Length of the air path

$I_0 := 1$ $\qquad$ Assume one unit of incoming intensity

$I := I_0 \cdot exp\left(-\mu_{air} \cdot x\right)$ $\qquad$ Escaping intensity, from eqn.(6.27) with *B*=1

$E := E\gamma \cdot \left(I_0 - I\right)$ $\qquad E = 3.306 \cdot 10^{4} \cdot eV$ $\qquad$ Deposited energy in 10 m of air

Hence $\qquad n := \frac{E}{w}$ $\qquad n = 972$ $\qquad$ ion pairs