(8.1) 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 as:

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

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

$E_\alpha := 5 \cdot 10^6 \cdot eV$ $w := 34 \cdot eV$ eV/ion pair from Table 8.1 $n := \frac{E_\alpha}{w}$

$n = 1.471 \cdot 10^5$ ion pars

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

$E_\beta := 1 \cdot 10^6 \cdot eV$ Hence $n := \frac{E_\beta}{w}$ $n = 2.941 \cdot 10^4$ ion pairs

(c) The γ passes 10 m of air, hence only part of the energy will be deposited and form ion pairs:

$E\gamma := 1 \cdot 10^6 \cdot eV$ $\mu_{mair} := 0.026 \cdot \frac{cm^2}{gm}$ $\rho_{air} := 1.293 \cdot 10^{-3} \cdot \frac{gm}{cm^3}$

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

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

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

$I := I_0 \cdot exp(-\mu_{air} \cdot x)$ Escaping intensity, from eqn.(7.28) with *B*=1

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

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