Homework Set 4

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2/12/24

4.1) **Cross Section**

The reaction $^3H(d,n)^4He$ is investigated with deuterons of an energy $E_{\text{kin}} = 5\,MeV$ that are perpendicularly incident upon a tritium target with a mass occupation density $\mu_t = 0.2\,\frac{mg}{cm^2}$.

4.1.1) [5] How many neutrons per second pass through a detector with a receptive area of $A = 20\,cm^2$ that is placed at a distance $R = 3\,m$ from the target and under an angle $\vartheta = 30^o$ with respect to the deuteron beam direction, if the differential cross section $\frac{d\sigma}{d\Omega}$ at this angle is $13\,\frac{mb}{sr}$ and the deuteron current is $I_d = 2\,\mu A$?

4.1.2) [2] How many neutrons per second reach the detector, if the target is tilted by 10^o?

4.2) **Absorption Length**

A beam of particles n_a is incident upon a thick layer of an absorbing material with n_b absorbing particles per unit volume. How large is the absorption length $\lambda = \frac{1}{\sigma n_b}$, that means the distance in which the intensity of the beam is reduced by a factor of $\frac{1}{e}$, in the following cases?

4.2.1) [2] Thermal neutrons in cadmium with $\rho = 8.6\,g/cm^3$ and $\sigma = 24506\,barn$.

4.2.2) [2] $2\,MeV$-photons in lead with $\rho = 11.3\,g/cm^3$ and $\sigma = 15.7\,barn$.

4.2.3) [3] Antineutrinos from a nuclear power plant in the earth with $\rho = 5\,g/cm^3$ and $\sigma = 10^{-19}\,barn$ for the neutrino electron interaction by neglecting the neutrino nuclei interaction and an estimated $\frac{Z}{A} = 0.5$.

4.3) **Lorentz Scalars**

4.3.1) [6] Calculate the photon threshold energy for coherent η-photoproductiuon in ^{12}C. Use $m_\eta = 547.45\,\frac{MeV}{c^2}$, $m_{^{12}C} = 11178.02\,\frac{MeV}{c^2}$ and that ^{12}C in the reaction $^{12}C(\gamma,\eta)^{12}C$ remains in the groundstate.

4.4) **Radon Activity**

4.4.1) **[GS]** [5] Calculate the activity A of ^{222}Rn created in the decay chain of ^{238}U as a function of the decay constants λ of the *feeding* parent ^{226}Ra and the *draining* daughter ^{222}Rn.

4.4.2) **[GS]** [2] After a lecture theater, whose walls, floor, and ceiling are made of concrete $(10 \cdot 10 \cdot 4\,m^3)$ has not been aired for several weeks, a specific activity $A = 100\,Bq/m^3$ of ^{222}Rn is measured. How high is the concentration of ^{238}U in the concrete, if the effective thickness, from which the ^{222}Rn can diffuse, is $1.5\,cm$?