Homework 04 (26Oct23)

Name: `your name`

Guidance:

- Upload your answers in the Blackboard submission portal as:

  lastname-firstname-homework-xx.pdf or **lastname-firstname-homework-xx.ipynb**

Table of Problems

Problem 1 (30 pts)

A stable nuclide X is reacted with particle n (*e.g.* a neutron) to give a radionuclide Y with radioactive decay constant λ_Y. Denote c_{X0} as the concentration of X when the reaction starts, assume there is no Y when the reaction starts, and that Y reacts with the particle n. It is of practical importance to be able to quantify the variation of the concentration of Y with time. Please address the sub-problems below.

1.1)(6 pts) Write down the reaction mechanism.

Answer:

1.2)(6 pts) What is the final ($t \to \infty$) concentration of X and Y?

Answer:

1.3)(6 pts) What is the final ($t \to \infty$) concentration of the product of the radioctive decay of Y?

Answer:

1.4)(6 pts) What is the final ($t \to \infty$) concentration of the product of the reaction of Y with the particle n?

Answer:

1.5)(6 pts) What choice of values of parameters makes the concentration of Y zero at all times?

Answer:

Problem 2 (30 pts)

Consider the following reactions on a very thin foil:

$$^{32}\mathrm{S} + {}^{1}_{0}\mathrm{n} \longrightarrow {}^{32}\mathrm{P} + {}^{1}_{1}\mathrm{p}$$
$$^{32}\mathrm{P} \longrightarrow {}^{32}\mathrm{S} + {}^{0}_{-1}\mathrm{e} + {}^{0}_{0}\bar{\nu}_{\mathrm{e}}$$

2.1)(6 pts) What is the minimum neutron energy to advance the reaction?

Answer:

2.2)(6 pts) What is the threshold energy?

Answer:

2.3)(6 pts) If the neutron energy is 5.25 MeV what is the energy of the proton?

Answer:

2.4)(6 pts) If a constant neutron flux of 4 10^{13} neutrons/m^2/s falls onto the foil and there is no phosphorus at the start of the irradiation, derive an equation for the evolution of the number density of phosphorus.

Answer:

2.5)(6 pts) Compute the time for the activity of phosphorous to reach 95% of the steady state value.

Answer:

Problem 3 (40 pts)

Equal volumes of graphite and iron are mixed together. Fifteen percent of the volume of the mixture is occupied by air voids. Find the total macroscopic cross section for neutron collision at 1 MeV given the following data: $\rho_{\mathrm{C}} = 1.6\,\mathrm{g/cm}^3$, $\rho_{\mathrm{Fe}} = 7.7\,\mathrm{g/cm}^3$. Is it reasonable to neglect the cross section of air? Why?

Answer: