Homework 02 (23Sep24)

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 (10 pts)

In Problem 1 of Homework 1, you used a formula to calculate the atom density of U-235. State the formula and prove it mathematically.

Problem 2 (10 pts)

2.1)(5 pts) A proposed fusion reaction is as follows: $^{2}\text{H} + {}^{3}\text{He} \rightarrow {}^{4}\text{He} + {}^{1}_{1}\text{p}$. Calculate the Q value of the reaction and the partition of energy of the products.

Answer:

2.2)(3 pts) Is the above reaction a better proposition than the D-T reaction? Explain why or why not.

Explanation:

2.3)(2 pts) How can ^{3}He be produced?

Answer:

Problem 3 (35 pts)

The UMLRR advertised a ^{60}Co sphere with activity $A = 100\,$kCi.

3.1)(5 pts) Does the activity stay the same with time? If not, what is the value in 1 year?

Answer:

3.2)(2 pts) Is the mass of the sphere after 1 year more than the initial mass, less or the same? Why?

Answer:

3.3)(5 pts) Calculate the initial mass of the sphere and final mass after 1 year.

Answer:

3.4)(3 pts) Calculate the mass loss.

Answer:

3.5)(10 pts) Find an alternative way to calculate the mass loss and compare with 3.4).

Answer:

3.6)(10 pts) If the energy emitted in one year by the ^{60}Co source could be converted in electricity, how long a typical residence in Massachussets could be powered for in 2023? (assume a conversion efficiency of 20% and 602 kWh/month average residence usage in MA).

Answer:

Problem 4 (35 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 n_{X_0} as the number density (or number concentration) of X when the reaction starts (there is no production of X), assume there is no Y when the reaction starts, and that Y does not react with the particle n. It is of practical interest to know the maximum activity of Y and at what time the maximum is reached. Please address the sub-items below.

4.1)(5 pts) Write the reaction mechanism.

Answer:

4.2)(10 pts) Setup the mathematical model and state your assumptions.

Answer:

4.3)(10 pts) Calculate the maximum activity of Y and when it occurs relative to the beginning of the reaction.

Answer:

4.4)(10 pts) Often times when designing the irradiation apparatus for the reaction in Problem 4.1), the particle n spatial flux magnitude is wanted for a given production activity maximum $A_{Y,\mathbf{max}}$. Derive the equation needed to find this flux value and explain how to solve it.

Answer:

Problem 5 (10 pts)

A nuclear fission reactor operates at a power of 1.5 GW(t) for 1 year. Calculate the heat decay power:

5.1)(2 pts) 1 day after shutdown.

Answer:

5.2)(2 pts) 1 month after shutdown.

Answer:

5.3)(2 pts) 1 year after shutdown.

Answer:

5.4)(4 pts) Repeat the above for 6 months of operation and compare results.

Answer: