

Homework 03 (11Oct22)

Name: your name

Rubric for each assignment:

Context	Points
Precision of the answer	80%
Answer Markdown readability	10%
Code readability	10%

Guidance:

- This is an individual homework.
- 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)** Gamma photon.
- **1.1)**(5 pts) Rest mass.
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- **Problem 2 (15 pts)** U-235 cross sections.
- **2.1)**(5 pts) Total.
- **2.2)**(5 pts) Capture to fission.
- **2.3)**(5 pts) Comment.
- **Problem 3 (25 pts)** I-131 production.
- **Problem 4 (50 pts)** U-235 foil.
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- **4.2)**(10 pts) Mass change.
- **4.3)**(10 pts) Mass change model.
- **4.4)**(10 pts) Final mass.
- **4.5)**(10 pts) Time for 1% of mass variation.

Problem 1 (10 pts)

A gamma photon travels in empty space without losing energy.

1.1)(5 pts) If you could stop the gamma photon, what would the rest mass be?

Answer:

1.2)(5 pts) What is the mass of the photon in motion as a function of frequency?

Answer:

Problem 2 (15 pts)

Cross sections of ^{235}U at 1 MeV are as follows: $\sigma_a = 2.1$ b, $\sigma_{\text{in}} = 1.8$ b, $\sigma_f = 1.2$ b, and $\sigma_e = 3.3$ b. Other cross sections can be considered negligible. Compute at this energy:

2.1)(5 pts) The total cross section.

Answer:

2.2)(5 pts) The capture-to-fission cross section ratio.

Answer:

2.3)(5 pts) Comment on this ratio in relation to fast neutron fission reactors.

Answer:

Problem 3 (25 pts)

The fission product ^{131}I has a half-life of 8.03 days and it is produced in fission with a yield of 2.9%, that is, 0.029 atoms of ^{131}I are produced per fission. Calculate the equilibrium activity of this radionuclide in a reactor operating at 3.3 GW. Note: the charge of the electron is $1.60219 \cdot 10^{-19} \text{ C}$.

Answer:

Problem 4 (50 pts)

A very thin foil of pure ^{235}U is exposed to a neutron flux of $10^{14} \text{ neutrons/cm}^2\text{-s}$. Interaction data: $\sigma_a = 684 \text{ b}$, $\sigma_f = 585 \text{ b}$. Pertinent questions follow.

4.1)(10 pts) Write down the major nuclear reactions taking place in the foil.

Answer:

4.2)(10 pts) Does the mass of the foil change? Explain whether it decreases, increases, or stays the same, and why.

Answer:

4.3)(10 pts) If the mass of the foil changes, derive a formula of its variation with time relative to its initial value. Explain the assumptions in your model.

Answer:

4.4)(10 pts) Using the derived formula, what is the final value of the mass of the foil relative to its initial value?

Answer:

4.5)(10 pts) Using the derived formula, how long does it take for a relative variation of mass of 1% to occur, if any?

Answer: