Homework 05 (07Nov22)

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)

Calculate the neutron slowing down decrement for natural UO_2. Does the presence of oxygen have a significant effect on the slowing down decrement?

Answer:

Problem 2 (10 pts)

Calculate Σ_a for:

1. Water of unit density at 25.3 meV
2. Water of 0.7 g/cc at 25.3 meV
3. Water of 0.7 g/cc at 25.3 1 eV

Answer:

Problem 3 (10 pts)

The first resonance in the scattering cross section of the nuclide ^{A}Z occurs at 1.24 MeV. The separation energies of nuclides ^{A-1}Z, ^{A}Z, ^{A+1}Z are 7.00, 7.50, and 8.00 MeV, respectively. Which nucleus and at what energy above the ground state is the level that gives rise to this resonance?

Answer:

Problem 4 (10 pts)

There is a prominent resonance in the total cross section of ^{56}Fe at 646.4 keV. At what energy, measured from the ground state, is the energy level in ^{57}Fe that corresponds to this resonance?

Answer:

Problem 5 (10 pts)

The excited states of ^{17}O occur at the following energies (in MeV) measured from the ground state: 0.871, 3.06, 3.85, 4.55, 5.08, 5.38, 5.70, 5.94, etc. At roughly what energies would resonances be expected to appear in the neutron cross section of ^{16}O?

Answer:

Problem 6 (10 pts)

A 2-MeV neutron traveling in water has a head-on collision with an ^{16}O nucleus.

1. What are the energies of the neutron and nucleus after the collision?
2. Would you expect the water molecule involved in the collision to remain intact after the event? Why or why not?

Answer:

Problem 7 (10 pts)

Derive the head-on elastic scattering energy ratio $\frac{E'}{E} = \left(\frac{A-1}{A+1}\right)^2$ covered in the classroom.

Answer:

Problem 8 (10 pts)

The average fractional energy loss of elastic scattering is defined as $\overline{\frac{E-E'}{E}}$. Show it is equal to $\frac{(1-\alpha)}{2}$ where α is the head-on elastic scattering energy ratio (Problem 7). Compute and plot the result as a function of the mass number A of the target nucleus. Evaluate the average fractional energy loss of elastic scattering for ordinary water.

Answer:

Problem 9 (10 pts)

A 1.5-MeV neutron in a heavy water reactor collides with an ^{2}H nucleus. The lethargy is defined as $\ln \frac{E}{E'}$ where E is the incoming neutron energy and E' is the scattered neutron energy. Calculate the maximum and average values of lethargy in the collision.

Answer:

Problem 10 (10 pts)

A power reactor is cooled by heavy water (D_2O) but a leak causes a 1 atom % contamination of the coolant with light water (H_2O). Determine the resulting percentage increase or decrease in the following characteristics of the coolant:

1. Slowing down decrement
2. Slowing down power
3. Slowing down ratio

Answer: