Homework 05 (06Nov23)

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)

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 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: