**Georgia Institute of Technology**

The George W. Woodruff School of Mechanical Engineering

Nuclear & Radiological Engineering/Medical Physics Program

Ph.D. Qualifier Exam

Fall Semester 2017

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Your ID Code

**NRE Reactor Physics**

**(Day 2)**

Instructions

1. Use a separate page for each answer sheet using only one side of the paper. DO NOT write on the BACK of the answer sheet.
2. The question number and your ID Code should be shown clearly on each answer sheet.

3. **ANSWER 4 OF 6 QUESTIONS ONLY.**

4. Staple your question sheet to your answer sheets and turn in.

**NRE Reactor Physics**

**Answer any 4 of the following 6 questions**

**Question 1:**

Calculate the neutron energy spectrum $ϕ\left(E\right)$ from a mono-energetic source emitting neutrons at $E\_{0}$ energy in an infinite hydrogen medium. Assume that the scattering cross section is constant and the absorption cross-section is inversely proportional to the neutron velocity.

**Question 2:**

Iodine (I) and Xenon (Xe) are produced in fission events. Iodine decays to Xenon which subsequently can either decay or absorb a neutron.

1. What should be the maximum value of the flux such that there will be no increase in Xenon concentration following shut-down. Explain why this is happening.
2. The reactor operates with a nominal power. If the power increases what will happen to the Xenon reactivity worth.

Use the following data:

$σ\_{a}^{Xe}=2.6×10^{6} b, t\_{1/2}^{I}=6.6 h, t\_{1/2}^{Xe}=9.1 h, γ^{I}=0.061, γ^{Xe}=0.003, ν=2.46$

**Question 3:**

The power in a reactor is doubled in 5 minutes by inserting a fixed positive reactivity. Calculate the stable period of the reactor and the inserted reactivity value. $β=0.0065$, $λ=0.08 sec^{-1}$ and $Λ=10^{-3} sec$.

**Question 4:**

A bare 40 cm slab reactor with homogeneously distributed fuel is given. The group constants are given in the following table:

|  |  |  |  |
| --- | --- | --- | --- |
|  | Group 1 | Group 2 | Group 3 |
| $$χ$$ | 0.580 | 0.430 | 0.000 |
| $$νΣ\_{f}, cm^{-1}$$ | 0.010 | 0.020 | 0.180 |
| $$Σ\_{a}, cm^{-1}$$ | 0.005 | 0.030 | 0.120 |
| $$Σ\_{s}^{g⟶g+1}, cm^{-1}$$ | 0.083 | 0.124 | 0.000 |
| $$D, cm^{-1}$$ | 2.160 | 1.720 | 0.350 |

Calculate the neutron energy spectrum (in 3 groups) and the criticality value. Assume that there is no up-scattering and only scattering to adjacent groups is possible. Describe your solution in details.

**Question 5:**

A spherical reactor composed of 235U metal is operating in a critical steady state. Discuss what probably happens to the multiplication of the reactor and why, if the system is modified in the following ways (treat each modification separately, not cumulatively):

a. The reactor is rapidly compressed to one-half its original volume.

b. A reactor operator accidentally sits on the reactor, squashing it into an ellipsoidal shape.

c. A thick sheet of cadmium is wrapped around the outside of the reactor. (Cadmium has large thermal absorption cross section).

d. The reactor is suddenly immersed in a large container of water.

e. A source of neutrons is placed near the reactor.

f. Another identical reactor is placed a short distance from the original reactor.

g. One simply leaves the reactor alone for a period of time.

**Question 6:**

A critical reactor at a reference state may be described with a loss operator, L, and production operator, P, as:

[L – λP] Φ = 0

A perturbed state is described by:

[L’ – λ’P’] Φ’ = 0

where

L’ = L + ΔL

λ’ = λ + Δλ

P’ = P + ΔP

Φ’ = Φ + ΔΦ

Develop a perturbation theory expression for Δλ and show that the adjoint flux Φ+ reduces the error to second order.