**Georgia Institute of Technology**

The George W. Woodruff School of Mechanical Engineering

Nuclear and Radiological Engineering/Medical Physics Program

PhD Qualifying Exam

Fall 2019

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(Your ID Code)

**Nuclear Engineering**

**Radiation Physics and Transport**

**(Day 2)**

**Instructions**

1. Use a separate page for each answer sheet using only the front 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 2 OF 3 Questions in each section; you will have answers for 2 Radiation Physics questions and 2 Radiation Transport questions**
4. Staple your question sheet to your answer sheet and turn in

**Radiation Physics**

**Radiation Physics Question 1.**

Oxygen-15 is a short-lived positron emitter (2 minutes). It is often produced at a cyclotron by bombarding nitrogen-14 target with energetic deuterons.

* 1. Write down this complete reaction.
	2. Is there an energy threshold of deuteron for this reaction? If “yes”, estimate this energy threshold. If “no”, explain why.
	3. Assuming the incident deuteron is 5 MeV, calculate the maximum energy of an outgoing neutron.
	4. Calculate the maximum energy of a positron emitted from oxygen-15.

**Radiation Physics Question 2.**

A 54Mn sample with mass 2 g and density 7.3 g cm3 is exposed for 2 minutes in a thermal neutron field with a flux density of 1013 cm2 s-1. What is the activity of the sample immediately after the exposure as a result of the radioactive 55Mn (half life = 2.579 h) produced by reactions in the sample? (Assume that the thermal-neutron, microscopic, cross section for 54Mn is = 13.3 b and that for 55Mn is 66.5 b)

**Radiation Physics Question 3.**

In the mixture of isotopes normally found on the earth at the present time, 238U has an abundance of 99.3% and 235U has an abundance of 0.7%. By assuming that they were equally abundant when the uranium in the earth was originally formed, estimate how much time has elapsed since the time of formation. (Assume that the measured lifetimes of these radioactive isotopes are 6.52\*109 and 1.02\*109 years respectively.)

**Radiation Transport**

**Radiation Transport Question 1**

Assume that the angular flux in a 1-D slab has the following form:

Using the Legendre polynomials, find an expression for the angular flux that assumes linear anisotropy.

Hint: and

**Radiation Transport Question 2**

Derive the dispersion relation for the asymptotic relaxation length (1/*k*) of the following transport equation.

Note:

**Radiation Transport Question 3**

Consider a homogenous slab with vacuum boundary, there is an isotropic surface source located at the left boundary, i.e. for

* 1. Write down the uncollided neutron transport equation and boundary condition
	2. Derive the total uncollided outgoing partial current at the boundaries
	3. Compute the first-flight escape and collision probabilities.