**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 Radiation Physics & Transport**

 **(Day 1)**

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 2 OF 3 Questions in each section; you will have answers for 2**

**Radiation Physics questions and 2 Transport questions.**

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

**NRE Radiation Physics**

**Answer any 2 of the 3 questions** **in Radiation Physics**

**Use the Nuclear Wallet Cards booklets for any nuclear data or physical constants you need.**

**Question 1:**

The neutron cross section data for 16O show that there is a resonance at 450 keV and that the resonance width is 40 keV.

(a) What is the energy level (from the ground state) of the compound nucleus (i.e. 17O) that corresponds to this resonance?

(b) What are the possible  for the corresponding excited state of 17O?

(c) Which type of neutron interaction is this resonance most likely associated with? e.g. (n, γ), elastic scattering, inelastic scattering, (n, 2n), (n, p), (n, fission), etc. Justify your answer quantitatively.

**Question 2:**

As shown, a 10-MeV electron beam is brought to perpendicularly impinge on a thin (10 μm) tungsten foil. Given that the collision stopping power of 10-MeV electron in tungsten is 2.3 keV μm-1, that the radiative stopping power is approximately equal to the collision stopping power, and that the CSDA range for 10-MeV electron in tungsten is 3.2 mm,

1. Draw the energy spectrum of the bremsstrahlung x-ray, justify why the spectrum appears the way it is, and then use it to estimate the average energy of the x-ray?

(b) For a beam current of 1 μA, estimate the x-ray emission rate (photons sec-1) and the rate of heating (in Joules sec-1) in the tungsten foil.

10 μm tungsten

10-MeV

electrons

Transmitted electrons

Bremsstrahlung x-ray

**Question 3:**

In many cases the decay of radionuclides is accompanied by the creation of new ones, either from the decay of a parent or from production by nuclear reactions such as cosmic ray interactions in the atmosphere or from neutron interactions in a nuclear reactor. Consider a radionuclide being so created.

1. If *Q(t)* is the rate at which the radionuclide of interest is being created,  is the decay constant for this nuclide, and N0 is the amount of nuclide present at time t=0 (when radionuclide creation begins), derive an integral expression for N(t), the amount of radionuclide at a time t.
2. Solve the expression in (a) for the specific case of where the radionuclide creation is constant Q(t) = Q0
3. Solve the expression in (a) for the specific case of a three component decay chain

**NRE Transport**

**Answer any 2 of the 3 questions** **in Transport**

**Use the Nuclear Wallet Cards booklets for any nuclear data or physical constants you need.**

**Question 4:**

One of the assumptions made in the derivation of the neutron transport equation is to assume that “neutrons have no memory.” That is, is independent of what happens to the neutron in the past (collisions). Describe in detail what this means and under what conditions this assumption breaks down or holds.

Additionally, describe three other assumptions and their validity.

**Question 5:**

Given the energy and time independent integrodifferential transport equation given below derive the corresponding integral transport equation.

,

where,

Q=S

.

**Question 6:**

Suppose that a point neutron source with the angular distribution of is located at the center of a homogeneous sphere with radius of . The vacuum boundary condition is assumed.

1. Write down the transport equation for the uncollided flux and boundary condition.
2. Derive the escape probability and the first-flight collision probability.
3. Write down the uncollided equations and the corresponding boundary condition.