**Georgia Institute of Technology**

The George W. Woodruff School of Mechanical Engineering

Nuclear & Radiological Engineering/Medical Physics Program

Ph.D. Qualifier Exam

Fall Semester 2015

\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Your ID Code

**Radiation Physics (Day 1)**

Instructions

1. Use a separate page for each answer sheet (no front to back answers)
2. The question number should be shown on each answer sheet

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

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

**NRE/MP Radiation Physics**

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

**Any nuclear data or physical constants you need should be in the Nuclear Wallet Cards booklets.**

Question 1.

1. Write down the Bethe expression for stopping power of a medium for a charged particle passing through it.
2. Define each term in this expression (numerical values not needed) and explain which terms depend on the medium and what terms depend on the charged particle.
3. The stopping power of a heavy charged particle Albertium (energy T1, mass m1, charge +1, Atomic number Z1, Mass Number A1) is S and its range is R. What are the stopping power and the range of the particle Bohrium (energy T2, mass m2, charge +2, Atomic number Z2, Mass Number A2) that has the same velocity as Albertium with Z2=2\*Z1 and A2=3\*A1? Express your answers in terms of S and R.

Question 2.

 The gamma rays from As-76 decay can be used to produce photoneutrons in beryllium.

* 1. What is the energy of the neutron emitted at 0 degrees from the direction of the incident gamma ray if it is the 1.7877 MeV gamma ray?
	2. What is the energy of a neutron emitted at 180 degrees from the direction of the incident gamma ray if it is the 1.7877 MeV gamma ray?
	3. What does (a) and (b) tell you about the neutron energy spectrum?
	4. How much As-76 is required to produce 106 neutrons per second (use table on the next page)?

|  |  |
| --- | --- |
| **Nuclide** | **(MeV)** |
| As-76 | -72.2908 |
| Be-9 | 11.3484 |
| neutron | 8.0713 |
| Be-8 | 4.9416 |
| As-75 | -73.0337 |



Question 3.

 In the following reaction: , use the atomic mass table (Attachment A) to evaluate (a) the energy level (above the ground) and  of , and (b) the energies of  and , respectively? Note: nth is a thermal neutron whose kinetic energy is approximately 0.025 eV.

Question 4.

A radiation detection system measures the background activity as 10.33 Bq. When a radioactive sample is moved into the detection area, the measured activity is 76.20 Bq. After exactly 120 minutes, the measured activity becomes 42.79 Bq. In all above measurements, the detector is kept on for exactly 100 seconds.

1. Calculate the decay constant and the half-life time of the radioactive sample.
2. Calculate the standard deviations for the answers of a).

Question 5.

Oxygen-15 is a short-lived positron emitter. It is often produced at cyclotron facilities by bombarding nitrogen-14 with deuterons. i.e.

 

If the reaction takes place by compound nucleus formation and the deuteron beam has an energy of 10 MeV, what is the probability that the generated neutrons are observed in the forward direction of the LAB system.

Question 6.

Consider the following decay chain:

$$A→B→C\left(stable\right), A→D(stable),A→E(stable)$$

Initially, there are only *N* A-nuclei and no other nuclei. Calculate the time that the activity of *B* to *C* decay reaches the maximum.