NRE Ph.D. Qualifier Exam
Day 1
Fall 2004

GEORGIA INSTITUTE OF TECHNOLOGY

The George W. Woodruff
School of Mechanical Engineering

Ph.D. Qualifiers Exam – Fall Semester 2004

Day 1: Radiation Physics
Exam Area

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Assigned Number **(DO NOT SIGN YOUR NAME)**

- Please sign your name on the back of this page—

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Ph.D. Qualifier Exam

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__________________ Your ID Code

Radiation Physics

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.

RADIATION PHYSICS

Answer 4 of the following questions.

1. Co-59 is to be irradiated in a thermal neutron flux to create Co-60. The thermal flux is 10^{15} n/cm^2-sec.
   a. After how many days of irradiation does the Co-60 activity reach a maximum?
   b. If it is irradiated at a flux of 10^{12} n/cm^2-sec, does the maximum Co-60 occur for the same irradiation time?

   Data:
   Half of Co-60 = 5.27 years
   2200 m/s ^{59}Co(n,γ)^{60}Co = 37.2 b

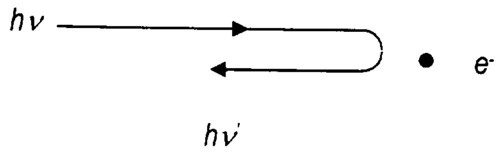
2. It is desired to make a Z° particle via the following proton-proton reaction.

$$p + p \rightarrow p + p + Z^{\circ}$$

   a. If the reaction is generated by colliding a proton beam with a fixed liquid hydrogen target, to what energy must the protons be accelerated to provide sufficient energy and momentum to create a Z° particle?
   b. Instead of using a fixed target, two opposing proton beams (that is, going in opposite directions) are collided, to what energy must the protons be accelerated for there to be sufficient energy for the reaction to occur?

   Data:
   Rest Mass of a proton = 0.938 GeV/c^2
   Rest Mass of a Z^o particle = 91.187 GeV/c^2

3. As shown, a photon of energy $h\nu$ undergoes Compton scattering with an electron being at rest. Use the conservation laws of energy and linear momentum to show that the energy of the backscattered photon can be expressed as $h\nu' = \dfrac{h\nu}{1 + \dfrac{2h\nu}{m_0 c^2}}$, where m_0 is the rest mass of the electron.



4. For most of the non-fissile heavy elements being irradiated with thermal neutrons, what type of nuclear reaction most likely to take place? And why?
   (b) It is well known that photons of energies between 1 and 5 MeV are most difficult to shield. Why?

5. Show by classical calculations that when a neutron collides with a proton at rest, the relationship between the neutron energy T_n and the recoil proton energy T_p is $T_p = T_n (\cos \theta)^2$. Here θ is the angle between trajectories of the proton and the incident neutron.

6. Provide an estimate for the number of head-on collisions required to slow a 1 MeV proton to rest on interactions with electrons. Describe four major differences between electron and heavy charged-particle slowing down. (The proton is 1836 times heavier than the electron).