**Georgia Institute of Technology**

The George W. Woodruff School of Mechanical Engineering

Nuclear & Radiological Engineering/Medical Physics Program

Ph.D. Qualifier Exam

Spring Semester 2014

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

**Radiation Physics (Day 1)**

UUUUUUInstructions

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**

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

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

Q1. During a total period of T, a radiation detection system measures N decays on a radioactive sample with a known half-life t1/2.

* 1. What is the sample activity at the beginning of the measurement?
  2. Assume Poisson statistics on N, what is the optimal T such that your answer of a) is most reliable?

Q2. Consider a Thompson scattering experiment where photons hit a single bounded electron. A detector is placed at a distance of D from the bounded electron to measure the outgoing photons. The detector surface is perpendicular to the incident direction of photon beam. Derive the theoretical distribution of measured photons on the detector (i.e., the probability density distribution).

Q3. A 1 mCi source of 60Co is placed in the center of a cylindrical water filled tank with an inside diameter of 20cm and depth of 100cm. The tank is made of iron with a wall thickness of 1cm. What is the uncollided flux density at the outer surface of the tank nearest the source?

Assume that 60Co emits two 1.25 MeV photons per disintegration and that the mass interaction coefficients per gram of water (density 1 g/cm3) and iron (7.874 g/cm3) for photons are 6.32x10-2 cm2/g and 5.322x10-2 cm2/g respectively.

Q4. A radioactive source is prepared by chemically separating 90Sr from other elements. Initially the source contains only 90Sr (half life 29.12 years) but this radionuclide decays to a radioactive daughter 90Y (half life 64 hours) which, after some time reached secular equilibrium with its parent. What is the time after the source is created that the activity of the daughter is 90Y is within 5% that of the parent?

Q5. Fluorine-18 is the most widely used radioisotope for positron emission tomography. It is often produced at cyclotron facilities by bombarding oxygen-18 with protons. i.e.



(a) Should there be an energy threshold of proton for this reaction? If “yes”, then estimate this energy threshold. If “no”, then justify your answer.

(b) Assuming that the incident proton energy is 18 MeV, that the reaction can be considered as a compound-nucleus reaction, and that the emerging  nucleus is at the ground state, what is the maximum energy of the neutron emitted from this reaction?

Q6. Calculate: (a) the de Broglie wavelength of a 200-MeV proton, and (b) the maximum energy that a 200-MeV proton can possibly transfer to an atomic electron during a collision?

Appendix A



Appendix A (Cont’d)



