Georgia Institute of Technology

The George W. Woodruff School of Mechanical Engineering
Nuclear & Radiological Engineering/Medical Physics Program

Ph.D. Qualifier Exam

Spring Semester 2006

_____ Your ID Code

Radiation Biology and Oncology (Day 3)

Instructions

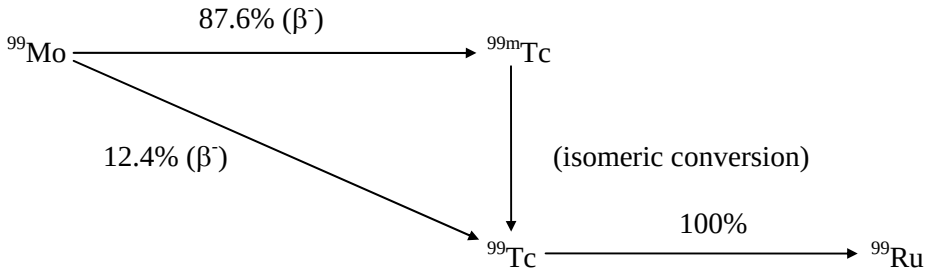
1. Use a separate page for each answer sheet (no front to back answers).
2. The question number should be shown on each answer sheet.
3. ANSWER 4 OF 6 QUESTIONS ONLY.
4. Staple your question sheet to your answer sheets and turn in.

NRE/MP Diagnostic Imaging Physics

Answer 4 of the following question.

1. Answer the Following Questions:
    a. What is the function of intensifying screens in x-ray imaging? How does an intensifying screen affect the image quality in terms of spatial resolution and signal-to-noise ratio (SNR)?
    b. What is "beam hardening" in x-ray CT? What does the "beam hardening effect" result in the reconstructed images? How can the effect be corrected?

2. You are given the following decay scheme and data for this question:



^{99}Mo half-life = 67 hours
^{99m}Tc half-life = 6.02 hours
^{99}Tc half-life = 2.22×10^5 years
^{99}Ru is stable

You are a medical physicist who has started a small firm manufacturing medical isotope generators. One of your products is a Mo-99/Tc-99m generator. Your company uses neutron bombardment of Mo-98 to make the radioactive Mo-99 parent for the generator kit. Neutron capture in Mo-98 occurs with a cross section of 0.53 barns (1 barn = 10^{-24} cm^2) and leads to radioactive Mo-99. Exactly, 1.0 μg of Mo-98 is placed in a neutron flux of 2.5×10^{13} neutrons/cm^2/s for 4.0 hours. The radioactive target is immediately removed from the neutron flux.

    a. Three hours after removal of the target, what is the activity of the Mo-99 in the target? (Express answer in Ci).

A hospital has received a shipment of your Mo-99 generator. The shipment contained 1000 mCi of Mo-99 when manufactured. It arrived at the hospital 48 hr after its production.

    b. If the generator is milked exactly upon arrival at the hospital, how much Tc-99m will be obtained? Assume that 95% of the available Tc-99m is eluted.
    c. If the generator is milked 24 hr after the initial milking, how much Tc-99m will be obtained?

3. How does the NMR signal depend on the magnetic field? Please also list factors contributing to this dependence. Explain T1-relaxation and T2-relaxation. How does signal in spin-echo imaging depend on T1 and T2?

4. Answer the following:

a. Use the stem cell theory (i.e. clonal expansion) to describe the multistep nature of carcinogenic process. What is the role of ionizing radiation in the process. Use graphs to assist your description.
b. What is epigenetics? How do epigenetic modifications affect carcinogenic process?

5. What are the 4 "R" of radiobiology? Include a description of the experimental setup (for CHC cells) from which 3 of the 4Rs were derived. How are they related to the fractionation schemes used in radiotherapy?

6. Explain each of the following (Total 10 points this question):
    a. What is the typical α/β ratio for late responding tissues (3 point)?
    b. What is the typical α/β ratio for early responding tissues (3 point)?
    c. How is this information used to optimize tumor kill while minimizing effects to normal tissues (4 points).