Phys 586 Final Exam

This is a closed book exam. Calculators are permitted. You are allow allowed one sheet of notes that you find useful. Most of the questions require just a couple of sentences or short word answers. There are two hours to complete the exam. Good luck!

1. ^{99m}Tc is produced using transient equilibrium. What is the condition for transient equilibrium? What is the parent nucleus and how is it usually created? Draw the activity as a function of time for both parent and daughter nuclei. Make sure to put (approximate) time units on the x-axis.

2. Describe how light is produced in an organic scintillator in response to a charged particle.

3. As regards plastic scintillators, what is Birk's law?

4. Excited nuclei decay by what two main processes? What factors determine the relative probability of the two processes?

5. Make a sketch of the mean energy loss dE/dx for heavy charged particles as a function of energy. What is the dependence on velocity at low energies? At very low energies, the ionization loss begins to decrease. Explain why.

6. In class we discussed both restricted energy loss and linear energy transfer. What does the term restricted refer to? Why would one want to use this restricted quantity instead of the unrestricted value?

7. Sketch the photon cross section (or equivalently, mass attentation coefficient) as a function of photon energy from 100 eV to 100 GeV. Indicate where the three main photon interactions contribute. I don't care about the values on the y-axis but match the values on the x-axis to your sketch. Write down the energy dependence of the three main photon interactions.

8. Briefly explain the differences in energy loss between electrons and protons. How does range as a function of distance curve differ between the two?

9. What does the abbreviation CSDA mean and how is it used (write an equation)?

10. Draw the absorbed dose versus depth curve for a monoenergetic photon beam. Qualitatively, how does the absorbed dose versus depth curve compare between neutrons and photons?

11. A promising cancer therapy is Boron Neutron Capture Therapy. Tumor cells are tagged with ^{10}B. The patient is then irradiated with epithermal neutrons. Explain why this could be an effective treatment and list an advantage compared with conventional radiation therapy.

12. What are the units of the first Townsend coefficient? What primarily determines the Townsend coefficient? What property of a proportional chamber does it describe?

13. In the AMS lab, we used an ionization chamber with two anodes, called E and dE. What was their function? How would they be used in typical AMS measurements?

14. Describe the operation of a Geiger counter. Why is a quencher gas needed for a Geiger counter?

15. With many different types of radiation detectors, we found in lab that the energy resolution $R = K/\sqrt{E}$ where K is some constant. Explain the origin of the $1/\sqrt{E}$ term.

16. For a given hypothesis and some experimental data, one finds $\chi^2 = 20$ for 6 degrees of freedom. This corresponds to a p-value of 0.003. Explain the meaning of the p-value. Would you reject the given hypothesis or not?

17. Why is it necessary to dope silicon in order to make a semiconductor detector? This would seem to greatly increase the number of free charge carriers which would make particle detection difficult.

18. What are the two modes of operation of a photodiode? Explain how each mode is used to detect light. Draw a Schottky photodiode. What is an advantage of this type of diode?

19. Consider an x-ray tube with target material X. Both characteristic and bremsstralhung x-rays are produced. If you wished to enhance the characteristic x-rays would you use the same or different material for a filter? Explain.

20. Briefly explain how a side-coupled linac structure is made possible. What is the advantage of this type of linac?