CHUKA  **UNIVERSITY**

UNIVERSITY EXAMINATIONS

THIRD YEAR EXAMINATION FOR THE AWARD OF DEGREE OF BACHELOR OF SCIENCE IN BIOCHEMISTRY AND BACHELOR OF SCIENCE IN MEDICINE

PHYS 394: RADIOBIOLOGY AND RADIOTRACER TECHNIQUE

TREAMS: BSC (BMED) AND BSC (BIOC) **TIME:2 HOURS**
DAY/DATE: FRIDAY 12/04/2019 **2.30 P.M – 4.30 P.M**

INSTRUCTIONS:

- **Answer Question One in Section A and any other Two Questions in Section B**
- **Do not write anything on the question paper**
- **This is a closed book exam, No reference materials are allowed in the examination room**
- **There will be No use of mobile phones or any other unauthorized materials**
- **Write your answers legibly and use your time wisely**

SECTION A

a. Define the terms
   i. Half-life
   ii. Disintegration constant
   iii. Radioimmunoassay
   iv. Photoionization (4 marks)

b. Radioisotopes are used to allow easier detection and measurements. List five qualities or criteria that radioisotopes must conform with. (5 marks)

c.
   i. What is linear attenuation coefficient? (1 mark)
   ii. The linear attenuation coefficient for 200 keV x rays in lead is 1.0×10^3 m^{-1}. What is the fraction of such photons remaining after penetrating a lead sheet of thickness 2.0 mm?
   iii. For gamma rays of energy *E*, the linear attenuation coefficient in material A is twice that in material B. Given that 80% of the gamma rays penetrate a given thickness of A, what fraction will penetrate the same thickness of B.

d. Different isotopes of fluorine are shown below.

Isotope	Stability
Fluorine-18	Unstable, beta plus decay
Fluorine-19	Stable,
Fluorine-20	Unstable, beta minus decay

i. What is an isotope? (1 mark)

ii. Why is fluorine useful for making a radiotracer? (1 mark)

iii. The isotope used in PET is flourine-18. Explain why the other isotopes of fluorine listed above are not suitable for PET. (2 marks)

e. The radioactive isotope carbon-11 used in PET is produced by firing high speed protons at nitrogen atoms.

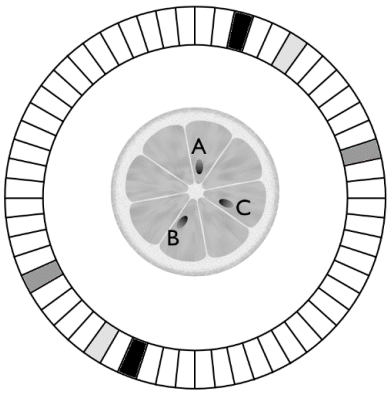
i. Why do the protons need to be travelling at high speed? (2 marks)

ii. How are protons accelerated up to high speeds? (1 mark)

iii. The nuclear reaction for the production of carbon-11 is shown below. Suggest what the particle (X) emitted in this process is. (1 mark)

$$^{14}_{7}N + ^{1}_{1}p \rightarrow ^{11}_{6}C + \mathrm{X}$$

f. The diagram below shows a slice of lemon in a (very small) PET scanner. ***One*** of the pips in the lemon is radioactive and is emitting positrons. Detectors shaded with the same shade of grey show pairs of gamma rays detected at the same time.



i. Which one of the pips is radioactive? (1 mark)

ii. How are these gamma rays created after a positron is emitted? (1 mark)

iii. Why do the gamma rays travel in opposite directions? (1 mark)

g. List three features that makes the liquid scintillation detector important for biologists.

(3 marks)

SECTION B
Question Two (20 Marks)

a. If a sample contains N nuclides, show that the rate number N and the rate R, are exponential functions of time, t. (4 marks)

b. Find the energy released/Q-value in the alpha decay of ^{238}U. Show that this nuclide cannot spontaneously emit a proton. You will find the following mass values useful.

(6 marks)

(^{238}U) =	238.050783 u
(^{234}Th) =	234.043596 u
(^{4}He) =	4.002602 u
(^{1}H) =	1.007825 u

c. The radioactive isotope, $^{14}_{6}C$ does not occur naturally but it is found at constant rate by the action of cosmic rays on the atmosphere. It is taken up by plants and animals and deposited in the body structure along with natural carbon, but this process stops at death. The charcoal from the fire pit of an ancient camp has an activity due to $^{14}_{6}C$ of 12.9 disintegrations per minute, per gram of carbon. If the percentage of $^{14}_{6}C$ compared with normal Carbon in living trees is 1.35×10^{-10} %, the decay constant is 3.92×10^{-10} s^{-1} and the atomic weight = 12.0, what is the age of the campsite? (3 marks)

d. The three types of radioactive decays interacts differently with matter. Explain how each type interacts with biological matter, giving that feature of the decay type responsible for these interactions. (7 marks)

Question Three (20 marks)

a. Instrumentation of radiation detection principles are based on how radiation interacts with matter. Mention three interactions that are useful in radiation detection. (3 marks)

b. With the aid of relevant sketches, explain the working of a Geiger Müller Counter. (4 marks)

c. Explain how the count rate varies with increase of voltage, starting with lower voltages than the starting voltage. (3 marks)

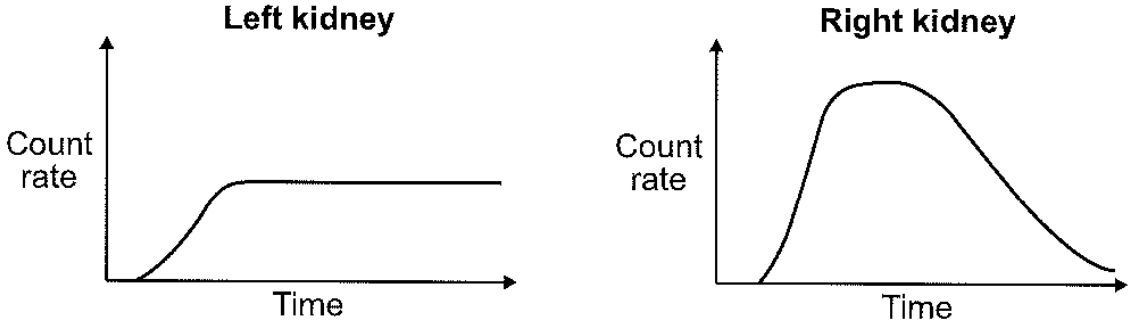
d. Explain how counting of discrete samples is done in Liquid Scintillation Counting and discuss why and how sample neutralization and decolorizing are done. (10 marks)

Question Four (20 Marks)

a. Explain briefly how PET is achieved. (4 marks)
b. Explain how PET would help to diagnose the following medical diseases and conditions
   i. Alzheimer disease (1 marks)
   ii. Brain Tumor (1 marks)
c. Explain briefly the principle of Radioimmunoassay. (5 marks)
d. Describe briefly how polyclonal antibodies are produced and explain the term polyclonal antibody ("polyclonal antibodies"). (4 marks)
e. List at least five advantages of methods based on radioimmunoassay. (5 marks)

Question Five (20 marks)

a. A doctor uses the radioactivity isotope technetium 99 m to out if a patient kidneys are working properly. The doctor injects a small amount of technetium-99 into the patient's bloodstream. The level of radiation emitted from each kidney is recorded on a graph.



i. What do technetium-99 emit? (1 mark)
ii. How do the + technetium-99 is passing through the bloodstream into each kidney? (2 marks)
iii. What do the graphs tell about the working of;
   1. The left kidney
   2. The right kidney

   Explain your answer. (4 marks)

iv. Sketch on the same axis the normal excretion pattern of the kidneys and the urinary bladder by detecting radioactivity. (2 marks)

v. Sketch, label and explain the phases in a Renographic Curve. (4 marks)

b. Radiopharmaceuticals in the heart can detected after administration. Explain how Multiple Gated Acquisition (MUGA) Studies are done and give 4 examples of different parameters for ventricular functions that can obtained. (7 marks)
