00303

# The Open University of Sri Lanka
## Faculty of Natural Sciences
## B.Sc/ B. Ed Degree Programme

| | |
|---|---|
| Department | : Physics |
| Level | : 5 |
| Name of the Examination | : Final Examination |
| Course Code and Title | **: PYU3167/PYE5167** |
| | **PHU5307/PHE5307- Medical Physics** |
| Academic Year | : 2019/2020 |
| Date | : 24th October 2020 |
| Time | : 1.30 p.m. -3.30 p.m. |

**General Instructions**

1. Read all instructions carefully before answering the questions.
2. This question paper consists of **6** questions in **4** pages.
3. Answer any **4** questions only. All questions carry equal marks.
4. Answer for each question should commence from a new page.
5. Draw fully labelled diagrams where necessary
5. Relevant log tables are provided where necessary.
6. Having any unauthorized documents/ mobile phones in your possession is a punishable offense.
7. Use blue or black ink to answer the questions.
8. Circle the number of the questions you answered in the front cover of your answer script.
9. Clearly state your index number in your answer script

Half-life of Po210 = 138.4 days

Avogadro number =$6.023 \times 10^{23}$

Linear attenuation coefficient for 1 MeV photon in lead = 0.78 $cm^{-1}$

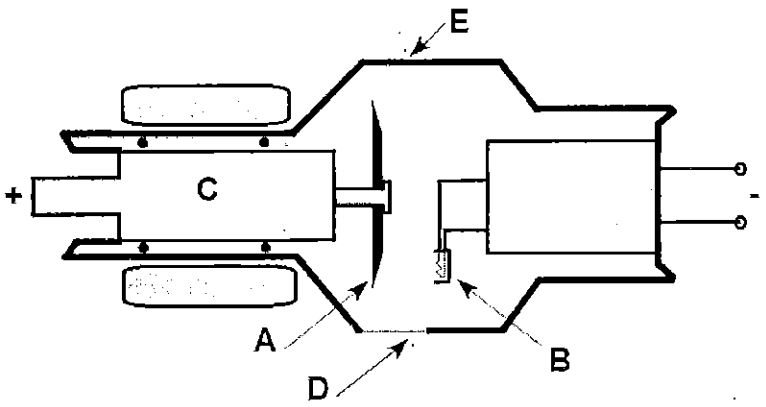
**Answer 4 questions only.**

**01.**

(a) What is meant by population inversion in lasers and explain why this is a necessary condition for lasing to take place? How population inversion is achieved in laser?

*(6 marks)*

(b) Label the parts, marked as A, B, C, D and E of a rotating anode X-ray tube in following figure.




(i) What is the use of part A?

(ii) Why B is a cup shaped metal assembly?

(iii) Why there is vacuum inside E?

*(4 marks)*

(c) When an incident beam of X-rays interacts with a matter placed in its path, what are the possible attenuation mechanisms happen according to the incident photon energies? Briefly describe each attenuation mechanism.

*(8 marks)*

(d) A monochromatic X-ray beam of intensity 7.5 W $m^{-2}$ is incident on a metal barrier of thickness 5 mm. For the particular X-ray beam, the half value thickness of that meatal is 3.5 mm. What will be the intensity after the beam has passed through the barrier?

*(7 marks)*

**02.**

(a) Optical fibers can be either coherent or non-coherent bundles. Describe how the fibers are arranged in each type of bundle.

*(2 marks)*

(b) What is the role of coherent and non-coherent fiber optic bundle in endoscopes?

*(3 marks)*

(c) Briefly explain how Ultrasound is generated using piezoelectric crystal with the aid of diagram.

*(5 marks)*

(d) Calculate the percentage of the sound intensity reflected when an ultrasound beam penetrates following tissue interfaces at a normal incidence.

(i) muscle to bone
(ii) muscle to air cavity

Explain the reflectivity and transmittivity of ultrasound beam in each tissue interfaces. Acoustic impedance is 1.7 g $cm^{-2}$ $s^{-1}$ in muscle, 7.8 g $cm^{-2}$ s-1 in bone and 0.00043 g $cm^{-2}$ $s^{-1}$ in air.

*(10 marks)*

(e) In a blood flow investigation, a pulsed Doppler ultrasound source of 6 MHz frequency is directed at an angle of $60^0$ with respect to the direction of the blood flow. The velocity of Ultrasound in the blood flow is 1.5 km $s^{-1}$ and average velocity of the blood is 0.045 m $s^{-1}$. What is the doppler frequency shift?

*(5 marks)*

**03.**

(a) What are the advantages of utilizing CT imaging over the projection type X-ray imaging?

*(4 marks)*

(b) How does Nuclear Medicine Imaging technique work?

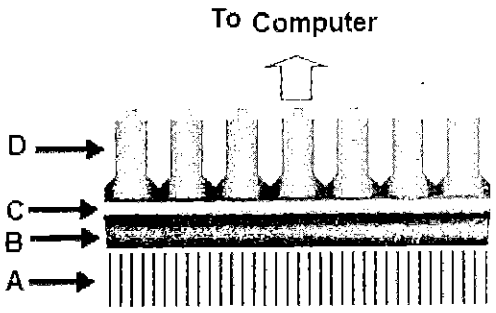
*(6 marks)*

(c) Compare the Imaging Modalities SPECT and PET.

*(3 marks)*

(d) The diagram shows major components of a Gamma camera.

*(7 marks)*




(i) Name the parts A, B, C, and D.

(ii) What are the main functions of part A and B?

(iii) What are the uses of part C and D?

(e) Brief the working principle of medical linear accelerator (LINAC). How a LINAC is used in cancer treatment?

*(5 marks)*

**04.**

(a) (i) What is meant by activity and half-life of a sample of radioactive nuclide?

(ii) An instrument containing $Po^{210}$ is obtained with an activity of 600 μCi. Estimate the decay constant and activity after 2 years?

*(8 marks)*

(b) (i) State the statistical law of radioactivity.

(ii) A sample of $Po^{210}$ shows radioactivity of 1000 disintegrations per second. Estimate the number of atoms in the radioactive sample.

(iii) What is the minimum mass of $Po^{210}$ in that sample?

*(6 marks)*

(c) Estimate the number of atoms in the above sample (in part b) after 50 days

*(3 marks)*

(d)

(i) Radiation levels can be expressed by Exposure (X) or absorbed dose (D). Define the terms Exposure or absorbed dose and state their units.

*(3 marks)*

(ii) During the cancer treatment of a patient, 4 Joule energy is deposited in a 0.5 kg tissue exposed to radiation. Find the absorbed dose delivered in Gy to the tissue?

*(3 marks)*

(e) A radioisotope is administered to a patient to treat a tumor. The physical half-life of this radioisotope is 6 h. The body excretes the isotope with a half-life of 10 h. Find the effective half-life of this radioisotope.

*(2 marks)*

**05.**

(a) Any practice resulting in increased exposure to radiation should be carefully planned in accordance with the three basic radiological protective principles as set out by the International Commission on Radiological Protection (ICRP) in 1991. What are those ICRP principles in radiation protection?

*(6 marks)*

(b) What is ALARA principle?

*(2 marks)*

(c) A health-care worker working in a radiation field can stay in a 2 R/hr field.

(i) If the dose is 300 mR, what is the minimum safest time in minutes to be at that working area?

(ii) The health-care worker works at 2 m distance from the source with same dose rate. How far he has to be away from the source, to lower the dose rate to 0.5 R /hr?

*(6 marks)*

(d) A person spends two minutes at 4 m distance from an unshielded 200 Ci Ir 192 source. What is the dose he received during his exposure to the gamma radiation?

($\Gamma = 0.48$ R $m^2$ $hr^{-1}$ $Ci^{-1}$)?

*(6 marks)*

(e) Shielding is one of the practical methods for reducing external radiation exposure.

(i) Estimate the dose rate after shielding a radiation source that emit 2 MeV photons, if the unshielded dose rate is 200 mR/hr and the source is shielded by 3 cm thick lead sheet.

*(2 marks)*

(ii) If the half value length of Copper for the above source is 0.95 cm, estimate the thickness required by a Copper shield to reduce the above unshielded dose exposure to 3.125 mR/hr.

*(3 marks)*

**06.**

(a) (i) What are free radicals? (ii) How do free radicals affect the body?

*(6 marks)*

(b) Briefly discuss the terms REB and LET, which describes the biological effectiveness of ionizing radiation in living tissues.

*(6 marks)*

(c) Radiation effects in human are typically classified into two classes: Somatic effects and genetic effects. Distinguish between these two effects of ionizing radiation?

*(4 marks)*

(d) Briefly discuss the imaging principle of MRI scan.

*(5 marks)*

(e) State 4 medical applications of MRI.

*(4 marks)*