1411E1188

Candidate's Seat No : _____

M.Sc. Sem.-3 Examination

502

Medical Physics

November-2025

Time : 2-30 Hours] [Max. Marks : 70

Q.1 Explain the principle of reactor-based production of radionuclides with a neat labelled diagram. Give a few examples of reactions. Discuss its advantages and limitations. [14]

OR

Q.1 Explain the basic principles and design of the Anger Gamma Camera. Discuss the detector components and different types of collimators used in the system. [14]

Q.2 Explain in detail the different imaging techniques used in nuclear medicine, including planar imaging, SPECT. Discuss the advantages and limitations of each. [14]

OR

Q.2 Describe the principle and working of Positron Emission Tomography (PET). Explain the process of annihilation photon detection, coincidence circuitry, and image reconstruction methods. [14]

Q.3 Calculate the shielding required for an uncontrolled room located below a PET uptake room. Patients are administered 555MBq of F-18 FDG, with 40 patients per week. The floor-to-floor distance is 4.3 m, and there is 10 cm of concrete between the two floors. Determine how much additional lead and concrete shielding would be required to keep the dose to the area below within uncontrolled area limits. [14]

OR

Q.3 Explain the working principle of a Negative ion cyclotron. How does it differ from a conventional positive ion cyclotron?

a) A cyclotron accelerates deuterons. What will be the frequency of the voltage source, if the value of magnetic field strength in the cyclotron makes 2 T and the mass of deuterons is 3.3×10^{-27}kg? [14]

b) If the same particle extract out of Dees with kinetic energy of 18MeV, then find out the cyclotron radius for particles.

Q.4 Describe the MIRD formalism (approaches) for internal radiation dosimetry. Deduce the fundamental MIRD equation and describe the practical procedure for obtaining each of the major contributing factors (Cumulative Activity and the S-factor [14]

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components). What are the limitations of the MIRD technique for internal radiation dosimetry?

OR

Q.4 What is compartmental analysis and describe its general assumptions. Make schematic diagrams (showing compartments, inputs, and transfer constants) and write down the corresponding differential equation for the concentration in the compartment(s) and sketch and interpret the characteristic time-concentration curve (solution curve) for the compartment for each of the following models: [14]

(a)Single Compartment model
(b)Two Compartmental model closed system
(c)Two Compartmental model open mammillary system
(d)Two compartment model open catenary system

Q.5 Attempt any **seven** out of twelve. (Each question is of **two** mark). [14]

(i) What are Singles, Random, and True events in PET imaging?

(ii) Why can't electrons be accelerated in a cyclotron? Give reason.

(iii) What are radiopharmaceuticals? Give examples.

(iv) If the daily dose limit for an occupational worker is 80 μSv and the dose rate in the Nuclear Medicine hot lab is 100 μSv/hr, how long can the worker stay in that area per day? What measures can be taken to reduce the radiation dose?

(v) What is the relation between absorbed fraction and specific absorbed fraction? State the condition in which both terms become equal?

(vi) A patient is administered a radiopharmaceutical. The Cumulative Activity measured in the liver (source) is 3.5×10^{12} Bq.s. Given the following S-factor:

$$S(\text{Liver} \leftarrow \text{Liver}) = 4.0 \times 10^{-11}\ \text{Gy/Bq.s}$$

Calculate the self-dose to the liver.

(vii) A patient undergoes a diagnostic thyroid uptake study using Iodine-131. A reference capsule (standard) of the administered dose is counted, yielding 20,000 counts per minute. The room background counted immediately after the standard is 100cpm. Patient Thyroid Count: The activity measured directly over the patient's thyroid gland is 9,500cpm. Patient Neck Background Count: The background activity measured over the patient's thigh is 500cpm. Calculate the percentage of thyroid uptake.

(viii) Patient is administered a radiopharmaceutical and it concentrates in the liver.

$$S(\text{kidney} \leftarrow \text{Liver}) = 1.2 \times 10^{-12}\ \text{Gy/Bq.s}$$

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If the total dose limit for the Kidney is 2Gy, what is the maximum permissible cumulative activity that could be allowed in the liver, assuming the liver is the only source organ contributing?

(ix) A Physicist is performing the linearity test on a dose calibrator using a ^{99m}Tc source. The initial measured activity of the source is 100 mCi at time t=0 hr. After 6 hours, the measured activity is 49 mCi. Calculate the percentage error in measurement in the dose calibrator. Given the half-life of ^{99m}Tc = 6 hrs.

(x) A cyclotron has an oscillator frequency of 15MHz. What should be the operating magnetic field for accelerating protons in radius of 0.8 meter? Also, calculate the kinetic energy (in MeV) of the proton beam produced by the accelerator?

(xi) a) The radionuclide ^{18}F is commonly produced by the reaction _____.

b) The target material for ^{18}F production is usually enriched _____ water.

(xii) a) The most common generator used in nuclear medicine is the $^{99}Mo/^{99m}Tc$ generator, where ^{99}Mo decays by _____ emission to produce ^{99m}Tc.

b) The isotope ^{131}I is produced in a reactor by the fission of _____.

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