RAJARATA UNIVERSITY OF SRI LANKA

FACULTY OF APPLIED SCIENCES

B.Sc. (General) Degree

Third Year – Semester I Examination – February/ March 2013

PHY 3211 – MEDICAL PHYSICS I

Answer any four (4) questions **Duration: 2 hours**

Charge of an electron(e) = 1.602×10^{-19} C, Planks Constant(h) = 6.63×10^{-34} J s
Speed of light (c) = 3.00×10^{8} m s^{-1}

1. (a) The equation $I = P / 4nr^2$ can be used to determine the intensity of X-rays from a source. Use this equation to show that the base units of intensity are kg s^{-3}.

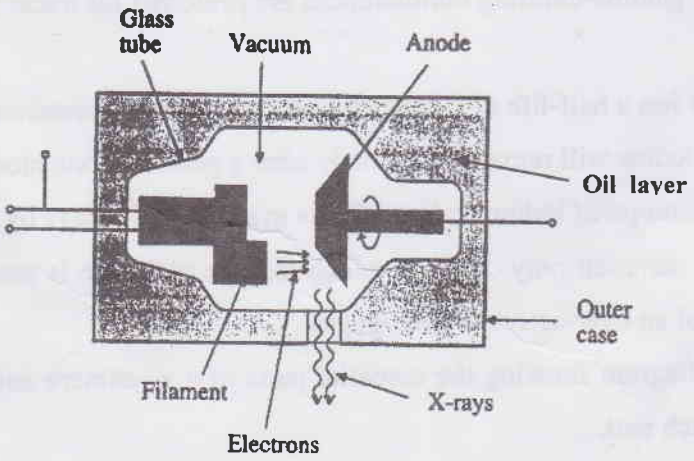
   (b) (i) The following figure shows part of a diagnostic X-ray tube.

   Suggest an appropriate operating voltage for this tube.

   Why is the anode rotated?

   Why is the X-ray tube evacuated?

   Suggest an appropriate material for the outer case.



(ii) State the function of the following parts of an X-ray tube:
the filament, the oil layer, the outer case.

(c) State two ways in which the radiographer is protected from over-exposure to X-rays. Explain why on an X-ray photograph, bones show up as bright areas and air spaces such as the lungs produce very dark regions.

(d) An X-ray beam has an intensity of 5.7 W mm $^{-2}$ at a distance of 0.4 m from an X-ray tube. How far from the X-ray tube should a radiographer stand in order to reduce the intensity to 0.80 W mm $^{-2}$?

(e) Why is the X-ray beam relatively more penetrating after it has been filtered? Suggest why it is beneficial to the patient to filter the beam.

2. (a) Distinguish among physical, biological and effective half life, and state the relationship among them.

(b) (i) Explain why the effective half-life of a radioisotope administered to a patient is less than the half-life due to radioactive decay.

(ii) ^{131}I has a radioactive half-life of 8 days and a biological half-life of 21 days. Calculate the effective half-life of ^{131}I .

(c) Give reasons why gamma-emitting radionuclides are preferred for tracer studies.

(d) (i) Iodine-131 has a half-life of 8 days. Approximately what percentage of a sample of iodine will remain in the body after a period of one month?

(ii) A second isotope of iodine, iodine-123, is available. It decays by emission of gamma radiation only. Explain which isotope of iodine is prefered for treatment of an over-active thyroid gland.

(e) Sketch a labeled diagram showing the essential parts of a γ –camera and explain the functions of each part.

3. (a) What is fluorescence yield ? Explain how fluorescence yield varies with atomic number of elements.

(b) Selection of radioactive materials for nuclear imaging process is depends on fluorescence yield. Explain why.

(c) Briefly explain, the key points which must be considered when selecting the radioisotope for nuclear imaging process?

(d) Technetium-99(^{99}Tc) is a widely used radioactive tracer in nuclear medicine because it has a physical half-life of six hours. Suggest why it is useful and suitable for use as a medical tracer.

(e) A sample of radioisotope (^{15}O) Oxygen-15, used in PET(Positron emission tomography) imaging of the brain, has an activity of 4.0 MBq. It has a half life of 2 minutes.

(i) Calculate its decay constant(λ)

(ii) How long will it take for the activity to fall to 1.5 MBq ?

4. (a) Define the following terms

(i) Radiation exposure

(ii) Absorbed dose

(iii) Equivalent dose

(iv) Effective dose

(b) Explain why Sievert (Sv) is a more suitable unit in Health Physics than Gray (Gy)?

(c) A cobolt-60 (^{60}Co) source gives a dose rate of 80 μSvh^{-1} at 1 m from it.

(i) At what distance from the source is the dose rate 25 μSvh^{-1} ?

(ii) What thickness of lead (Pb) ,placed 1 m from the source would give the same protection ?

(d) For a chest X-ray, assume that the approximate equivalent dose to the lungs is 36 μSv, to the red bone marrow 11 μSv, to the liver 16 μSv and to all other tissue 1 μSv per organ. Calculate the effective dose using following table.

Organ	Organ weighting factor (W_T)
Gonads	0.2
Lungs, red bone marrow, stomach, Colon	0.12(for each organ)
Thyroid, Liver, Oesophagus, Breasts, Bladder, Remainder	0.05(for each organ)
Skin, Bone surfaces	0.01(for each organ)

5. (a) Write short notes on the following:

(i) Mammography

(ii) Modern X-ray tube

(b) Briefly describe the attenuation mechanisms of X-rays with matter.

(c) Explain why the X-ray photons used in radiotherapy have higher energies than those in radiography.

(d) Discuss the relative effect on expected cell kill when treating a tumour with low LET(Linear Energy Transfer) radiation.

(e) A narrow beam containing 2000 photons is reduced to 1000 photons by a 10^{-2} m thick copper slab. What is the total linear attenuation coefficient of the copper slab for these photons?

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