Candidate No.: ________

The Royal Australian and New Zealand College of Radiologists

FRANZCR Examination Part I Radiation Oncology

Radiotherapeutic Physics

May 2009

Time Allowed: 3 Hours

INSTRUCTIONS

- There are a total of SIX questions.
- Write your answers in the book provided.

- All questions are of equal value. Sections within questions are not necessarily of equal value.

- All questions are to be attempted.
- You may use diagrams, tables or lists in your answers.
- Grid paper has been provided for optional use.
- Answers should be given from a radiotherapeutic physics viewpoint.
- Hand **all** papers to invigilator, no papers are allowed to be taken from the exam room. THIS INCLUDES EXAM PAPERS.

Question 1

a) Describe the principles of operation of a 0.6cc (Farmer-type) thimble ionisation chamber when used in an x-ray beam. (2 marks)

b) Draw a labelled diagram of a re-entrant (well-type) ionisation chamber when used for HDR Iridium-192 source calibration checks. (1 mark)

c) A new HDR Iridium-192 source is delivered with a certificate of calibration from the manufacturer stating the Air Kerma Rate at 1m from the source on a particular day and time. Describe the experiment and identify factors that need to be considered to confirm the source calibration with a 0.6cc thimble ionisation chamber. (3 marks)

d) Briefly describe the use of a suitable dosimeter for each of the following tasks in a HDR brachytherapy suite.

   i) Routine QA test of source position and dwell time accuracy. (1 mark)
   ii) Verify that source retraction has occurred into the lead safe. (1 mark)
   iii) Monitor the dose received by personnel during an emergency. (1 mark)
   iv) Monitor the dose received in the control area over a period of several months. (1 mark)

Question 2

a) Figure 1 depicts an axial section through the mid-thorax, irradiated with a single lateral photon beam (6 MV, 100 cm SSD). Explain how the presence of the lung will alter affect the dose delivered at the points 1, 2, 3 and 4. (2 marks)

b) Figure 2 depicts an axial section through the skull, irradiated with a photon beam. Explain how the presence of the bone will alter affect the dose delivered at the points 5, 6, 7 and 8 in the following photon beams: (4 marks)

i) 200 kV_p, 1.5 mm Cu HVL, 50 cm SSD

ii) 6 MV, 100 cm SSD

iii) 25 MV, 100 cm SSD

c) Figure 3 depicts an axial section through the pelvis, treated using a 3-field technique, where the isodose lines are calculated with the heterogeneity correction algorithm turned OFF. The patient has bilateral hip replacements with steel prostheses.

i) Describe the effects of the steel prostheses on the CT scan image and on the calculation of the isodose distribution. (2 marks)

ii) What steps might be taken to either improve the accuracy of dose calculation or avoid the problem? (2 marks)

FIGURE 1

Lung ρ=0.25

1: 0.5 cm superficial to lung
2: 1.0 cm from interface
3: 2.0 cm from interface
4: 3.0 cm from interface

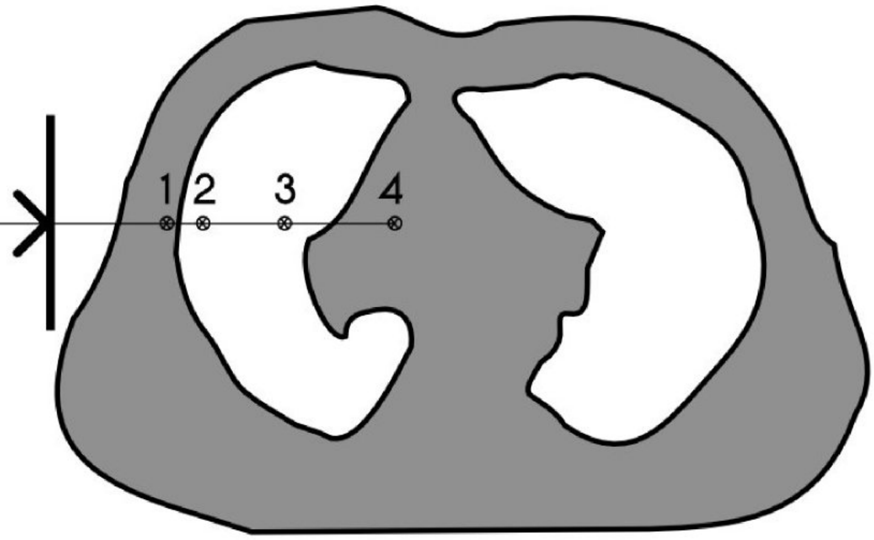


FIGURE 2

Bone ρ =1.65

5: 1.0 cm superficial to interface
6: bone mineral
7: soft tissue embedded in bone mineral
8: 3.0 cm deep to interface

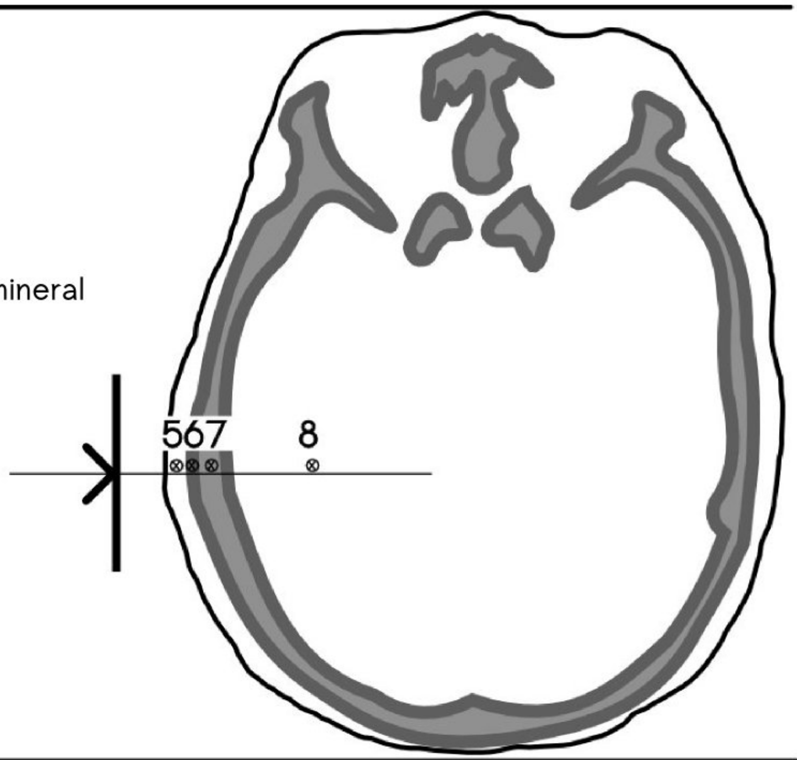
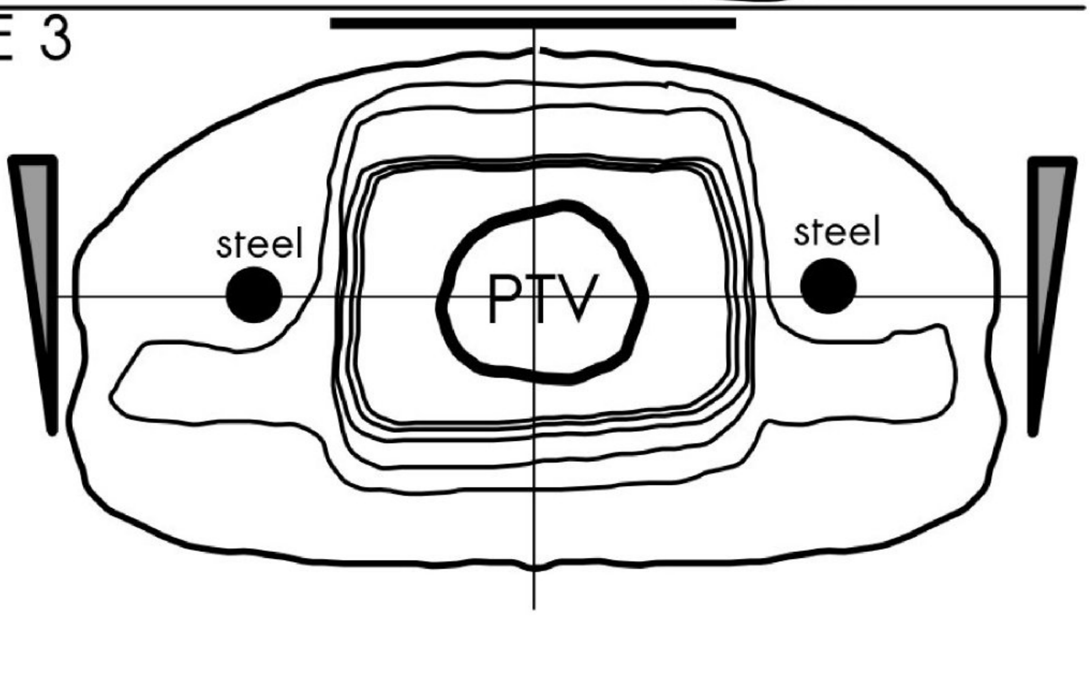


FIGURE 3



Question 3

a) Write brief notes on the following, including the units where appropriate:

i)	recommended dose limits	(1 mark)
ii)	half value layer	(1 mark)
iii)	Compton Effect	(1 mark)
iv)	the Bragg peak	(1 mark)
v)	remote afterloader	(1 mark)
vi)	decay constant	(1 mark)
vii)	the Gamma Knife	(1 mark)
viii)	the Paris System	(1 mark)
ix)	SSD and SAD monitor unit calculation methods	(1 mark)
x)	field size equivalent square	(1 mark)

Question 4

a) Draw an accurate diagram of the central axis depth dose curves in water, for 6 MeV, 12 MeV and 18 MeV electron beams of field size 10 x 10 cm at 100 cm FSD. Using this diagram, explain the physical reasons for the differences between each of the following clinically relevant portions of the curve

i)	the surface dose	(1 mark)
ii)	width of the 90% dose plateau	(1 mark)
iii)	the dose deposited deeper than the practical range (Rp)	(1 mark)

b) Draw an accurate diagram of the central axis depth dose curve in water, for a 6, 10 and 15 MV photon beam of field size 10 x 10 cm at 100 cm FSD. Using this diagram, explain the physical reasons for the differences between each of the following clinically relevant portions of the curve.

i)	the surface dose	(1 mark)
ii)	the depth of Dmax	(1 mark)

iii) the depth of D50% (1 mark)

c) Draw an accurate diagram illustrating the energy spectrum of both a ^{60}Co and a 6MV beam. Using this diagram, explain the reasons for the differences between each of the following:

i) peak energy (1 mark)

ii) mean energy (1 mark)

d) i) Draw the energy spectrum of a 6 MeV electron beam: (1 mark)

a) as the beam exits the waveguide window, and

b) at the depth of maximum dose inside the patient

ii) Explain why the beam spectrum is different in each of the cases described in d, (i) (1 mark)

Question 5

a) For each of the following applications, draw a well labeled schematic diagram of the components of a linear accelerator (linac) head in; (2 marks)

i) photon treatment mode

ii) electron therapy treatment mode

b) Describe the key function of each of the components in your diagrams. (3 marks)

c) Describe the spatial distribution of x-rays around a thin target, resulting from an electron beam incident on that target, with energies of a) 100 keV and b) 20 MeV. How has this distribution affected influenced the placement of targets in superficial and megavoltage radiation generators? (2 marks)

d) The attenuation of a photon beam in matter is caused by 5 major types of interactions. With the aid of diagrams, describe 3 of these interactions. (3 marks)

Question 6

a) With the aid of diagrams, describe two methods of wedge filtration commonly used in megavoltage photon treatments in clinical practice. (3 marks)

b) Consider each of the wedge filters described in your answer for part a) of question 6.

   i) Discuss the physical principles involved in their design. (4 marks)

   ii) Explain the similarities and differences in the dose distributions achieved in the patient. (1 mark)

c) Give two reasons why wedge filtration is used and a clinical example of each in practice. (2 marks)