The Royal Australian and New Zealand College of Radiologists®

The Faculty of Radiation Oncology

Candidate Number: ______

FRANZCR Examination

Phase 1 Radiation Oncology

Paper 1

6 September 2019

9:30am

Time Allowed: 2.5 Hours

INSTRUCTIONS

- There are a total of SIX questions numbered 1 – 6.
- Each question relates to one Oncology Science subject. The paper indicates which subject is being assessed in each question. The following abbreviations will be used:

  ANA = Anatomy
  PHY = Radiation Oncology Physics
  RCB = Radiation and Cancer Biology

- All questions are worth 15 marks each. **<u>The marks allocated to each sub-part of the questions are indicated in brackets.</u>**
- Write your answers in the book provided, or on the answer sheets provided as directed in the questions.
- Start each question on a new page.
- Only use a black or blue pen.
- All questions are to be attempted.
- You may use diagrams, tables or lists in your answers.
- Write your candidate number on each page used in the answer booklet.
- Hand **all** papers to the invigilator. No papers are allowed to be taken from the exam room. THIS INCLUDES THE EXAMINATION QUESTION PAPERS.

Question 1

ANA

a. Describe, in detail:

i. The course of the ureter, including key anatomical landmarks. **(2 marks)**

ii. The anterior and posterior relations of the right and left ureter. **(2 marks)**

b.

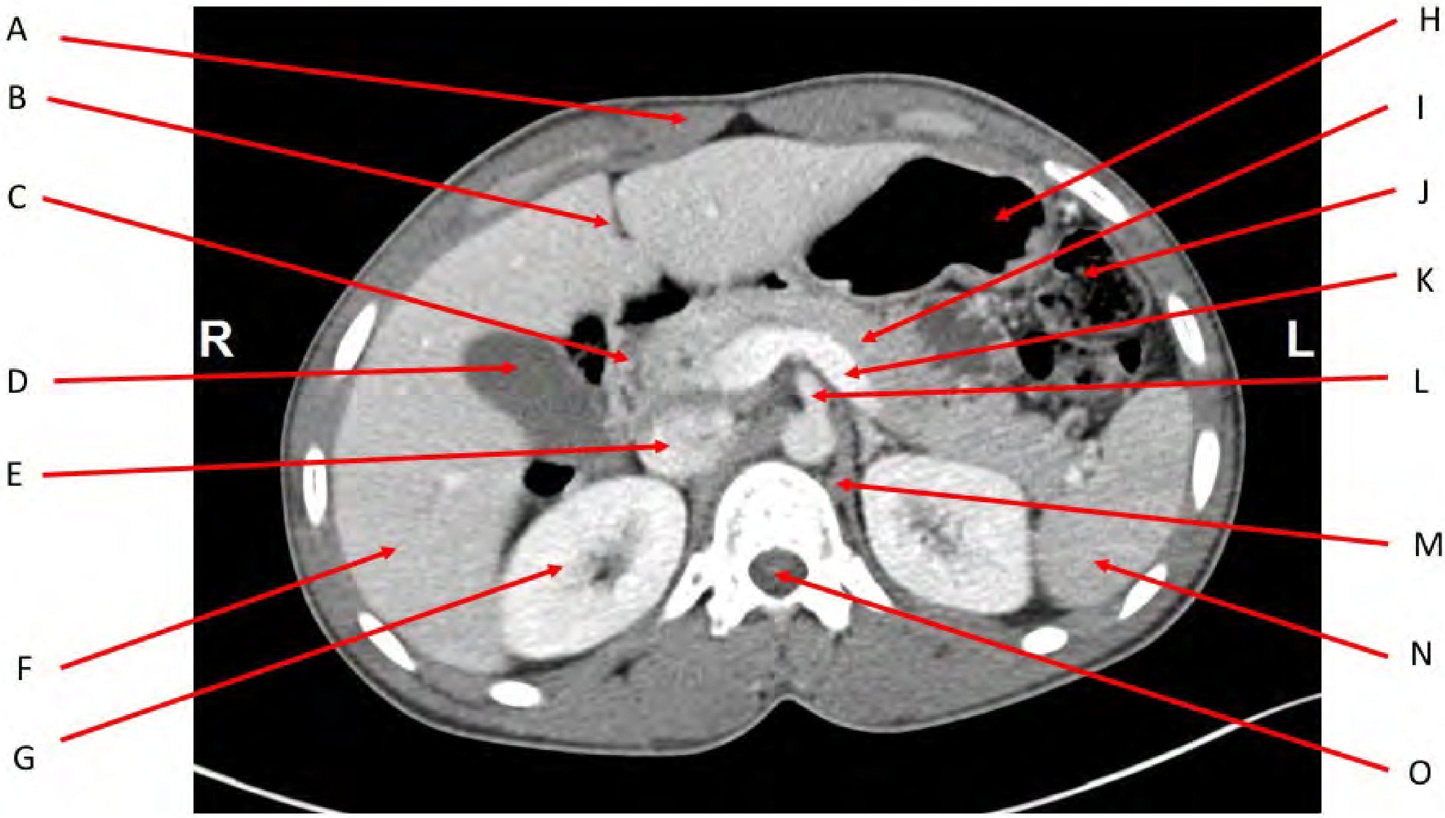
i. Draw a labelled diagram of the stomach (coronal view), including the subparts. **(2 marks)**

ii. Describe the arterial blood supply of the stomach in detail. **(3 marks)**

iii. Describe the lymphatic drainage of the stomach. **(3 marks)**

c. Name the structures labelled A to O on the contrast-enhanced axial CT abdomen image below. Indicate laterality where applicable. **(3 marks)**

(Answers are to be written in your answer booklet, not on the question paper)



Question 2

PHY

a. For radioactive sources, define the following terms in words: **(2.5 marks)**

- **i.** activity
- **ii.** specific activity
- **iii.** physical half-life
- **iv.** biological half-life
- **v.** effective half-life

Note: Units are not required.

b. Using a table, compare Iodine-131, Strontium-89 and Samarium-153, with regards to the following: **(4.5 marks)**

- **i.** type(s) of radiation emitted
- **ii.** physical half-life
- **iii.** physical form in which they are used and technique of delivery to patient
- **iv.** an example of clinical use

c. A woman is admitted to the ward for a therapeutic dose of Iodine-131.

- **i.** Outline the ward procedures in common use to minimise radiation hazards associated with patients treated with Iodine-131. **(2 marks)**

Several hours after receiving Iodine-131, the woman feels unwell and alerts nursing staff via the intercom. On approaching the room, the nurse finds the patient on the bed and a pool of vomit on the floor.

- **ii.** Outline an appropriate management plan for the above scenario. Include in your answer, the actions to be performed by the nurse, as well as subsequent management of the spill. **(2 marks)**

d.

- **i.** Define radioactive equilibrium. **(1 mark)**
- **ii.** Describe two (2) types of radioactive equilibrium and provide a radioisotope example for each in clinical use. **(3 marks)**

Question 3

RCB

The response of normal tissues to the radiation dose they receive can be very variable. Michalowski proposed a classification of normal tissues into hierarchical and flexible tissues to explain differences in radiosensitivity.

a. Briefly outline the concept of hierarchical (H-type) and flexible (F-type) tissues and what happens to these tissues at the time of and following radiation exposure. Provide a normal tissue example for each tissue type. **(4 marks)**

b. Define the term “tolerance dose”. **(1 mark)**

One factor in determining the tolerance dose of normal tissues is the organisation of the tissue in a model proposed by Withers which defined tissues as having a parallel or serial architecture.

c. Define a functional subunit (FSU). **(1 mark)**

d. Briefly describe the concept of parallel and serial architecture of normal tissues including how the radiation tolerance of an organ is affected by its organisation of FSUs. In your description, provide one example of an organ with parallel architecture and one example of an organ with serial architecture. **(3 marks)**

e. Define what is meant by the terms early and late radiation side effects and when they occur. **(1 mark)**

The tolerance doses of normal tissues, as defined by the QUANTEC papers, are commonly used by radiation oncology departments. However, it is not universally reliable.

f. Briefly outline six (6) limitations that need to be taken into account when using the QUANTEC tissue tolerances. **(3 marks)**

Radiation toxicity of normal tissues can be recorded using toxicity scoring systems.

g. Briefly explain the purpose of using toxicity scoring systems to record radiation toxicity. **(1 mark)**

h. Give an example of a toxicity scoring system for:

- **i.** Early radiation toxicity **(0.5 marks)**
- **ii.** Late radiation toxicity **(0.5 marks)**

Note: Specific gradings of these systems are not required.

Question 4

ANA

a. The mediastinum lies in the thorax and is divided into multiple compartments.

- **i.** What anatomical landmarks define the plane that demarcates the superior and inferior mediastinum? **(0.5 marks)**

- **ii.** Name the structure that divides the inferior mediastinum into anterior, middle and posterior compartments. **(0.5 marks)**

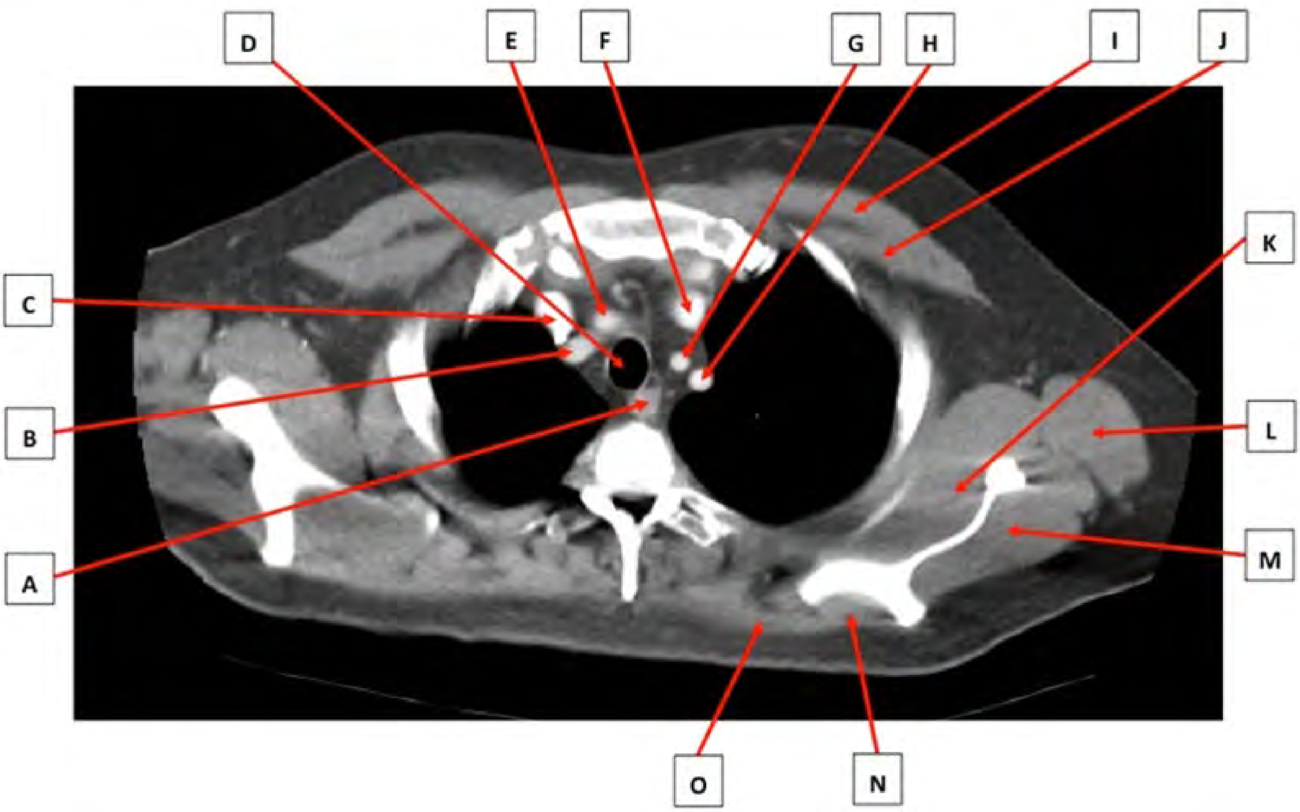
- **iii.** List twelve (12) structures found in the superior mediastinum. **(2 marks)**

b. Describe the course of the thoracic duct from its origin to end including key landmarks and its relation to the oesophagus. **(3 marks)**

c. Draw and label the trachea and bronchial tree to the level of segmental bronchi. **(4 marks)**

d. Name the structures labelled A to O on the axial CT chest image below. Indicate laterality where applicable. **(3 marks)**

(Answers are to be written in your answer booklet, not on the question paper)

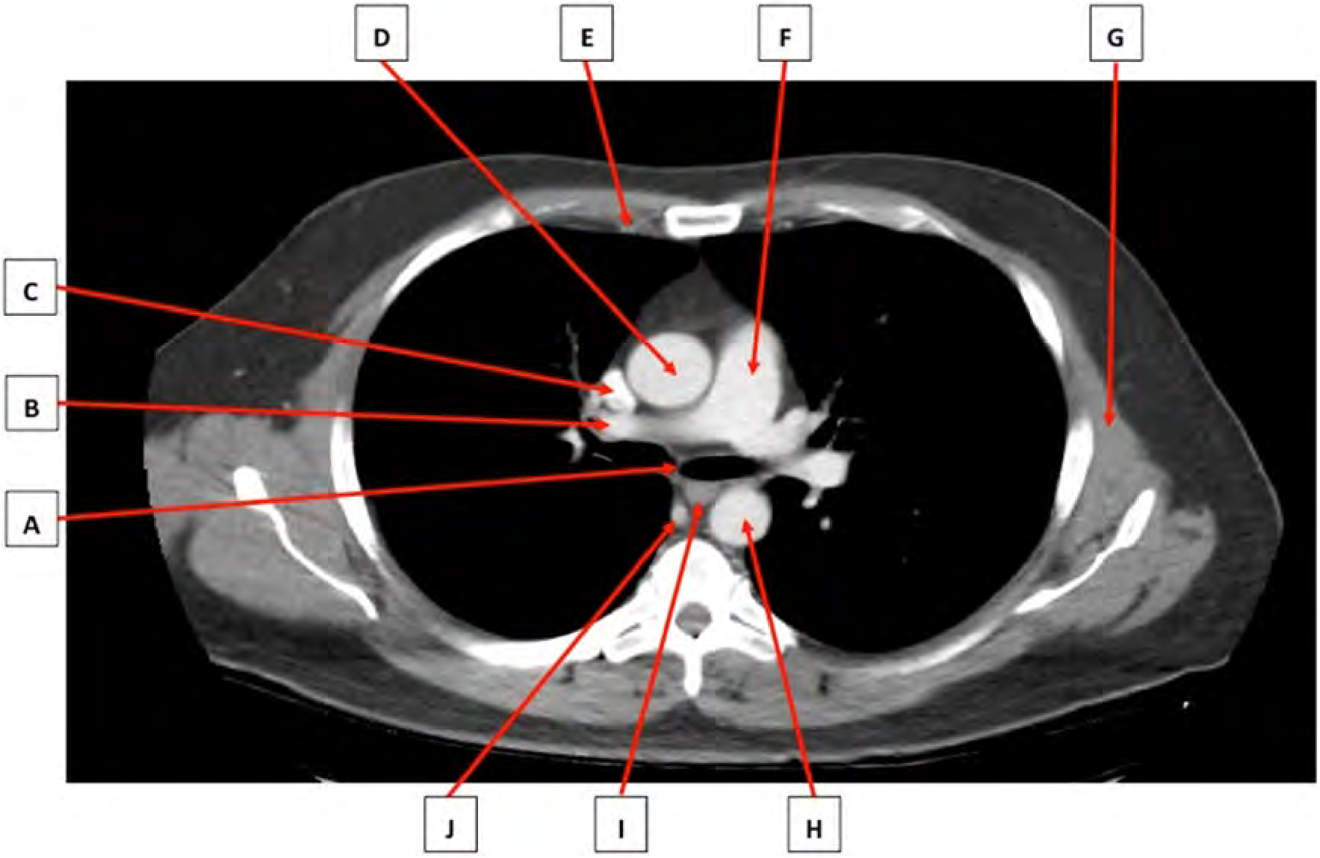


Question 4 cont

ANA

e. Name the structures labelled A to J on the axial CT chest image below. Indicate laterality where applicable. **(2 marks)**

(Answers are to be written in your answer booklet, not on the question paper)



Question 5

PHY

a. Photons interact with matter in four important processes: coherent scattering, photoelectric effect, Compton scattering and pair production

i. For each process, draw an annotated diagram to describe the interaction. **(4 marks)**

ii. State the interaction most relevant to megavoltage radiation therapy, and how it is influenced by atomic number. **(1 mark)**

b. Describe the physics principles behind how a CT data set is generated by a CT simulator. **(2 marks)**

c. Using a table, for each of the following techniques (i) to (iv) used to verify treatment accuracy, describe**:**

- one advantage compared to the others listed,
- one limitation in general,
- a suitable clinical scenario for its application; and
- a reason for your choice.

i. Skin tattoos and levelling lasers **(2 marks)**

ii. Electronic portal imaging **(2 marks)**

iii. Cone beam CT **(2 marks)**

iv. Fiducial marker **(2 marks)**

Question 6

RCB

a. In 1955, Thomlinson and Gray reported that malignant tumours are composed of hypoxic as well as well-oxygenated cancer cells and since then hypoxic tumour cells have been recognised as a major obstacle to the success of radiation therapy.

i. Define the Oxygen Enhancement Ratio (OER). **(0.5 marks)**

ii. The normoxic tumour receives a dose of 4Gy. On a labelled axis, draw a cell survival graph illustrating the difference between oxygenated cells and hypoxic cells with an OER of 3. **(2 marks)**

(Use the graph paper provided in your examination booklet)

iii. Explain how fractionated radiation therapy helps overcome tumour hypoxia. **(1 mark)**

iv. Explain how the following drugs work to overcome hypoxic radioresistance: **(3 marks)**

- Tirapazamine
- Nimorazole
- Nicotinamide and Carbogen

v. Apart from the methods discussed in (iii) and (iv) above, list three (3) other methods attempted to overcome radioresistance due to hypoxia. **(1.5 marks)**

b. Hypoxic stimuli also triggers changes to the DNA damage repair pathway through a key transcription factor.

i. Name the key transcription factor that plays a pivotal role in hypoxia related tumour radioresistance. **(0.5 marks)**

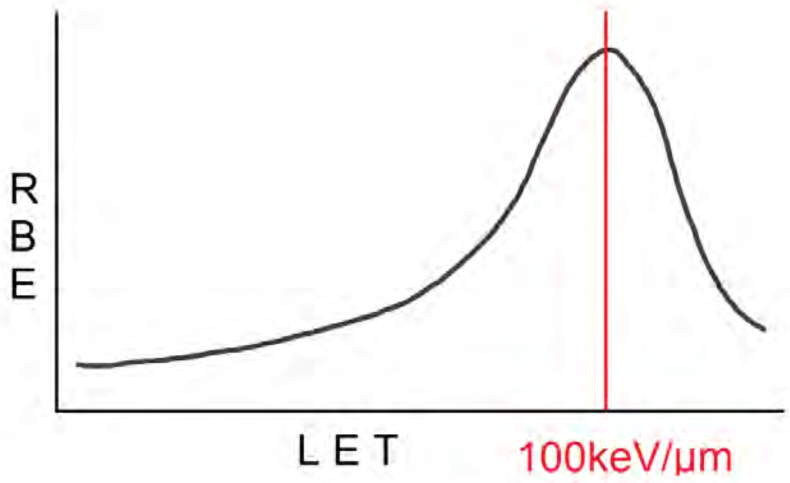
ii. Explain how this transcription factor is thought to affect: **(1.5 marks)**

- tumour vasculature
- tumour metabolism
- tumour metastasis

Question 6 cont

RCB

c. The relative biological effectiveness of ionising events produced by different ionising radiation varies enormously based on linear energy transfer as shown below:



i. Define "linear energy transfer" (LET). **(0.5 marks)**

ii. Define "relative biological effectiveness" (RBE). **(0.5 marks)**

iii. Explain why an LET of about 100keV/µm produces the optimal biological effect and why the RBE does not increase beyond this. **(1 mark)**

iv. Draw a labelled graph showing the relationship between OER and LET. **(3 marks)**

(Use the graph paper provided in your examination booklet)

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FRANZCR Examination

Phase 1 Radiation Oncology

Paper 2

6 September 2019

2.00pm

Time Allowed: 2.5 Hours

INSTRUCTIONS

- There are a total of SIX questions numbered 7 – 12.
- Each question relates to one Oncology Science subject. The paper indicates which subject is being assessed in each question. The following abbreviations will be used:

  ANA = Anatomy
  PHY = Radiation Oncology Physics
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Question 7

ANA

a.

i. Describe the relations of the prostate gland. **(2 marks)**

ii. Describe the zones within the prostate. **(2 marks)**

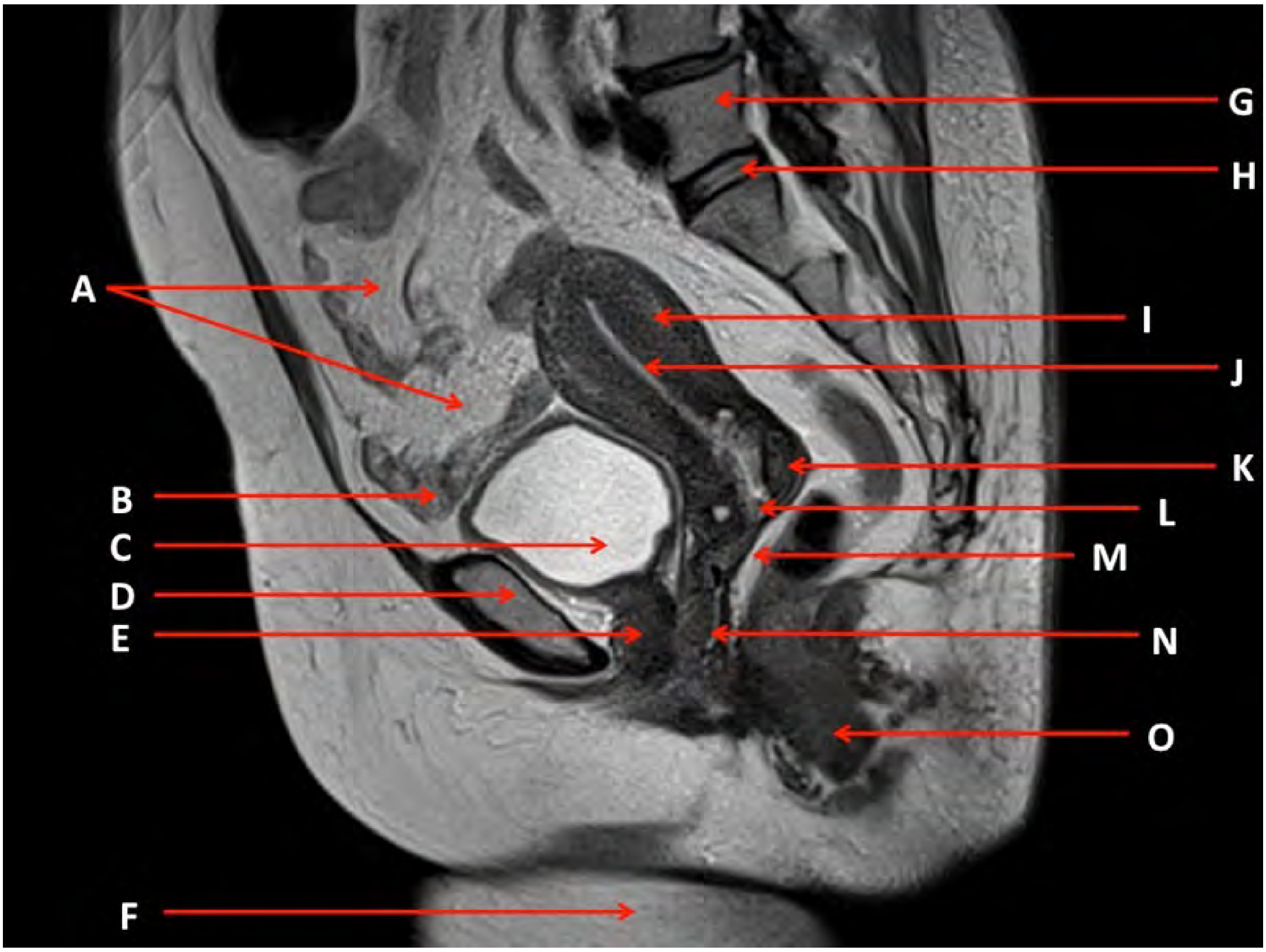
b. Describe the course of the male urethra. **(2 marks)**

c. Describe the histologic features of the cervix mucosa in a mature pre-menopausal adult woman. **(2 marks)**

d. Describe the lymphatic drainage of the cervix. **(2 marks)**

e. Name the structures labelled A to O on the sagittal MRI of a female pelvis below. **(3 marks)**

(Answers are to be written in your answer booklet, not on the question paper)

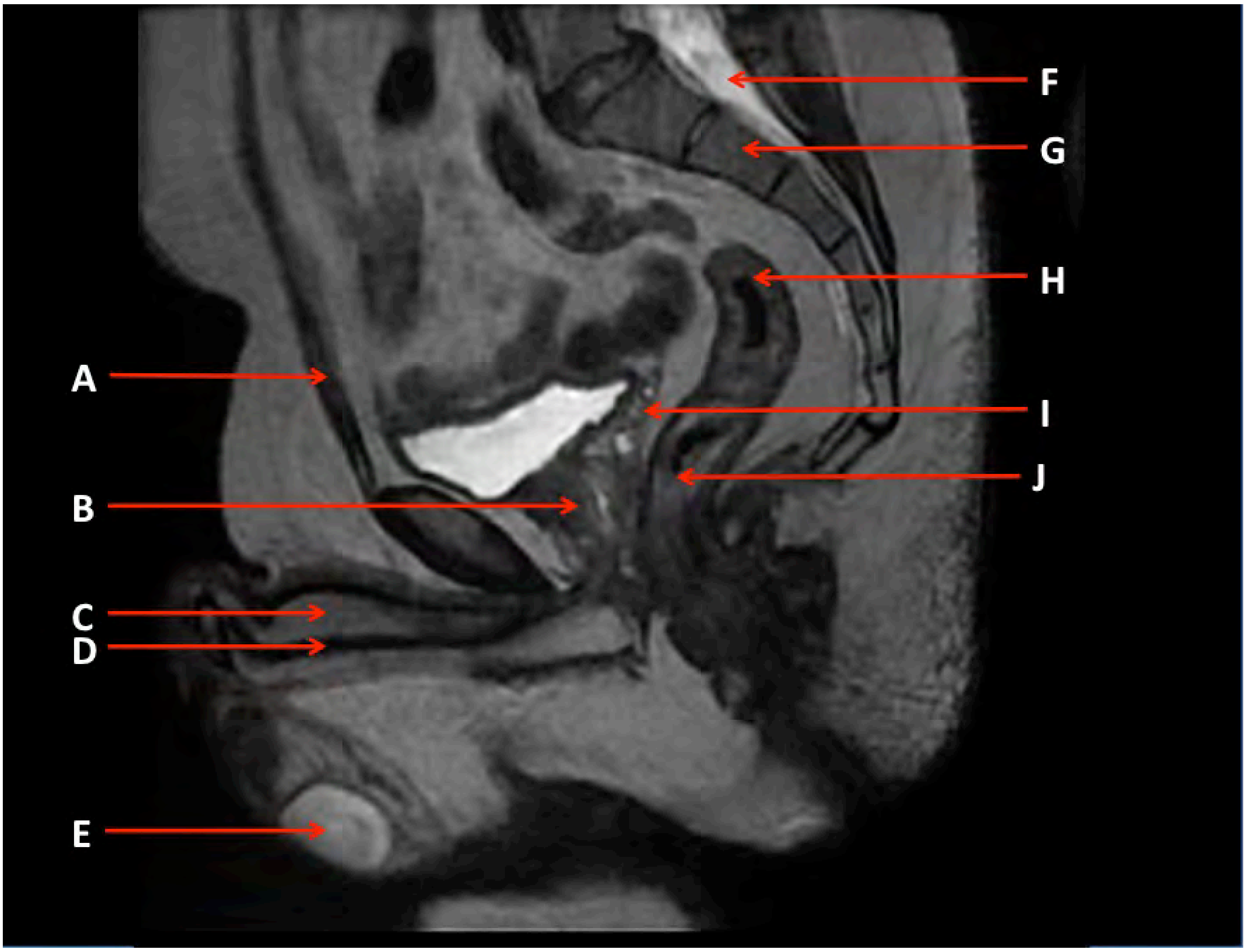


Question 7 cont

ANA

f. Name the structures labelled A to J on the sagittal MRI of a male pelvis below. **(2 marks)**

(Answers are to be written in your answer booklet, not on the question paper)



Question 8

PHY

a. Define the following terms: **(2 marks)**

- **i.** Half-value layer
- **ii.** Effective energy

b. A 200 kVp photon beam is generated by an x-ray tube with an inherent filtration of 1mm of aluminium.

- **i.** Draw a labelled diagram of the expected energy spectrum of this beam. **(2 marks)**
- **ii.** List three (3) aspects of the x-ray tube that may alter this energy spectrum. **(1 mark)**
- **iii.** Explain why this beam must be modified for clinical use and how this is achieved. **(2 marks)**
- **iv.** For a Thoraeus filter, describe the components and explain how they produce a more desirable energy spectrum. You may find it helpful to use diagrams to show how the spectrum is altered, however, diagrams are not required. **(2 marks)**

c. A 75 year old man presents with a skin cancer of the right medial canthus and is to be treated with radiation therapy. The radiation oncologist defines a target volume 1.5 cm long, 1.5 cm wide and 1.0 cm deep which is to be treated using either: **(4 marks)**

- **i.** kilovoltage photons
- **ii.** electrons

Discuss four (4) physical differences and dosimetric implications of treating the target volume with respect to these two treatment modalities.

d. Bolus is often prescribed when delivering radiation therapy. **(2 marks)**

- **i.** Describe three (3) reasons why bolus would be prescribed.
- **ii.** List two (2) examples of suitable bolus materials.

Question 9

RCB

a. On the same set of axes, draw and label a radiation dose response curve for: **(2.5 marks)**

i. an individual patient

ii. a patient population.

(Use the graph paper provided in your examination booklet)

b. For each of the categories of: **(3 marks)**

- patient factors
- tumour factors
- treatment factors

List two (2) factors which account for the difference in the individual patient and patient population curves.

c. Describe what is meant by the γ-value on a dose response curve. **(1 mark)**

d. Describe the process of vascularisation of tumours and why their growth rate depends on this. **(4.5 marks)**

e. Briefly outline which biological factors, with examples, may increase the therapeutic ratio when treating patients with radiation therapy. **(4 marks)**

Question 10

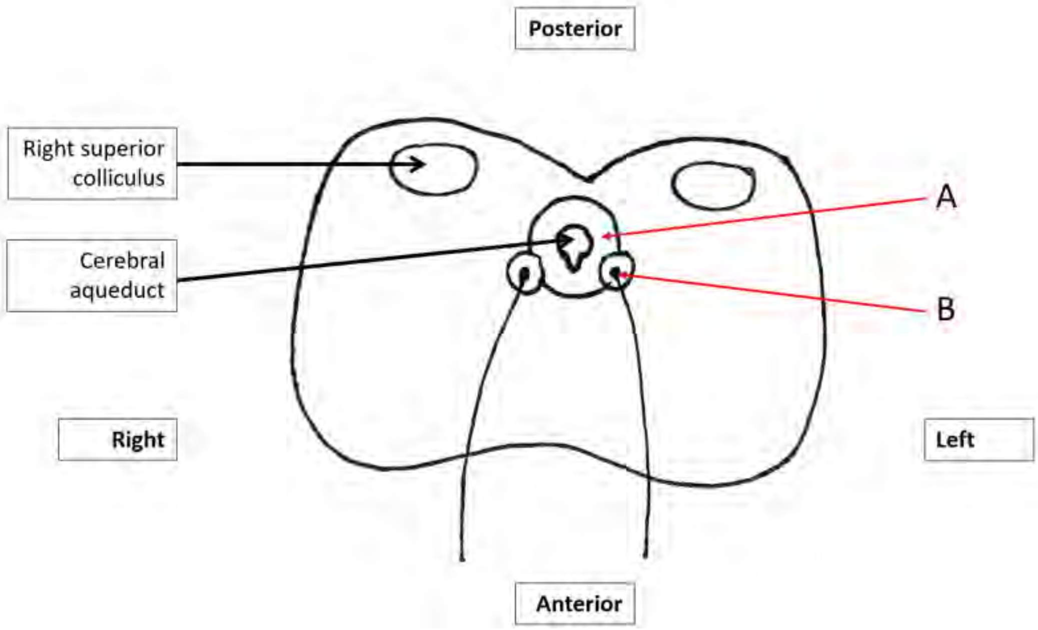
ANA

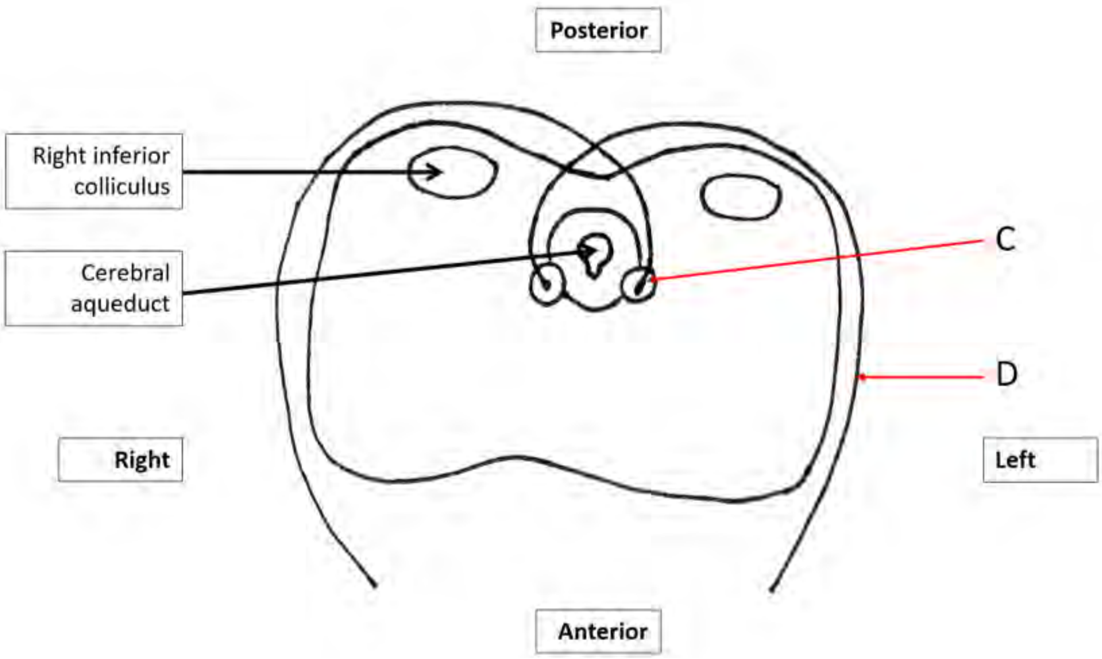
a. The brainstem consists of 3 essential substructures.

i. List the three (3) substructures. **(1 mark)**

ii. The following three (3) axial schematic diagrams illustrate important cranial nerve anatomy in the brainstem. Name the structures labelled A to G on the diagrams below. **(2 marks)**

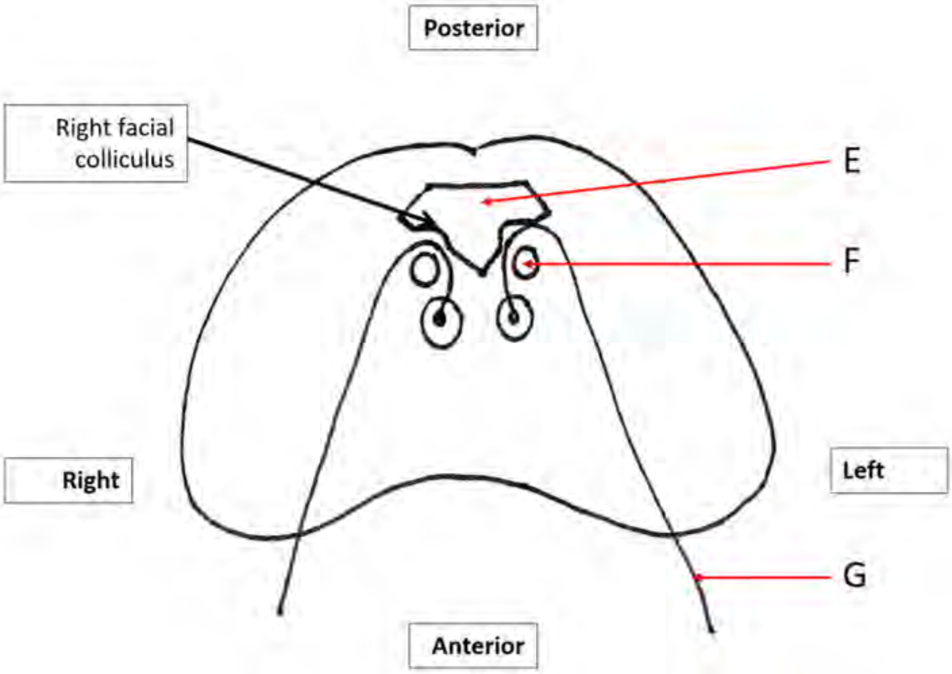
(Answers are to be written in your answer booklet, not on the question paper)





Question 10 cont

ANA



b. Describe the course of the vestibulocochlear nerve (8th cranial nerve). **(2 marks)**

c. With regards to the nasopharynx, describe the:

i. Relations **(2 marks)**

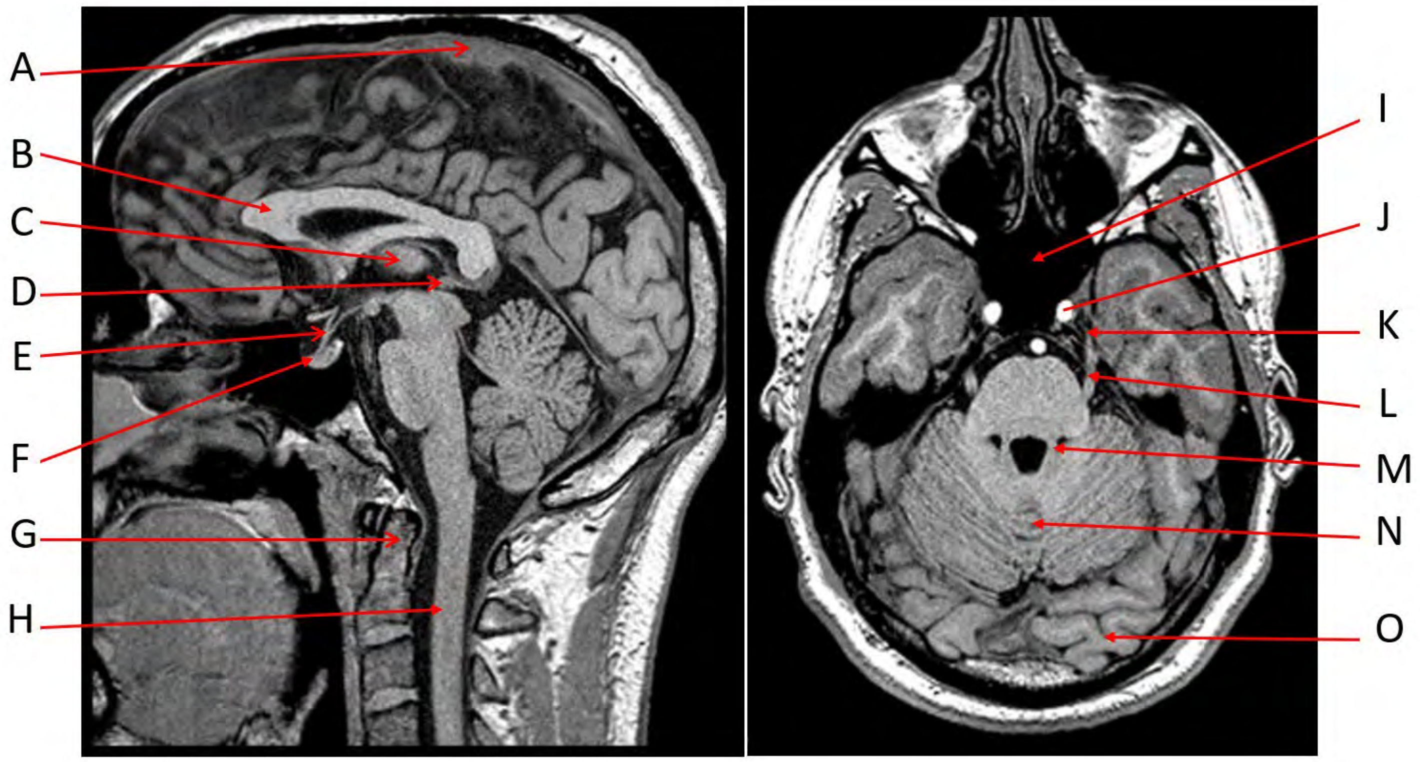
ii. Lymphatic drainage **(2 marks)**

Question 10 cont

ANA

d. On the following sagittal and axial MRIs of the head, name the structures labelled A to O. Indicate laterality if applicable. **(3 marks)**

(Answers are to be written in your answer booklet, not on the question paper)

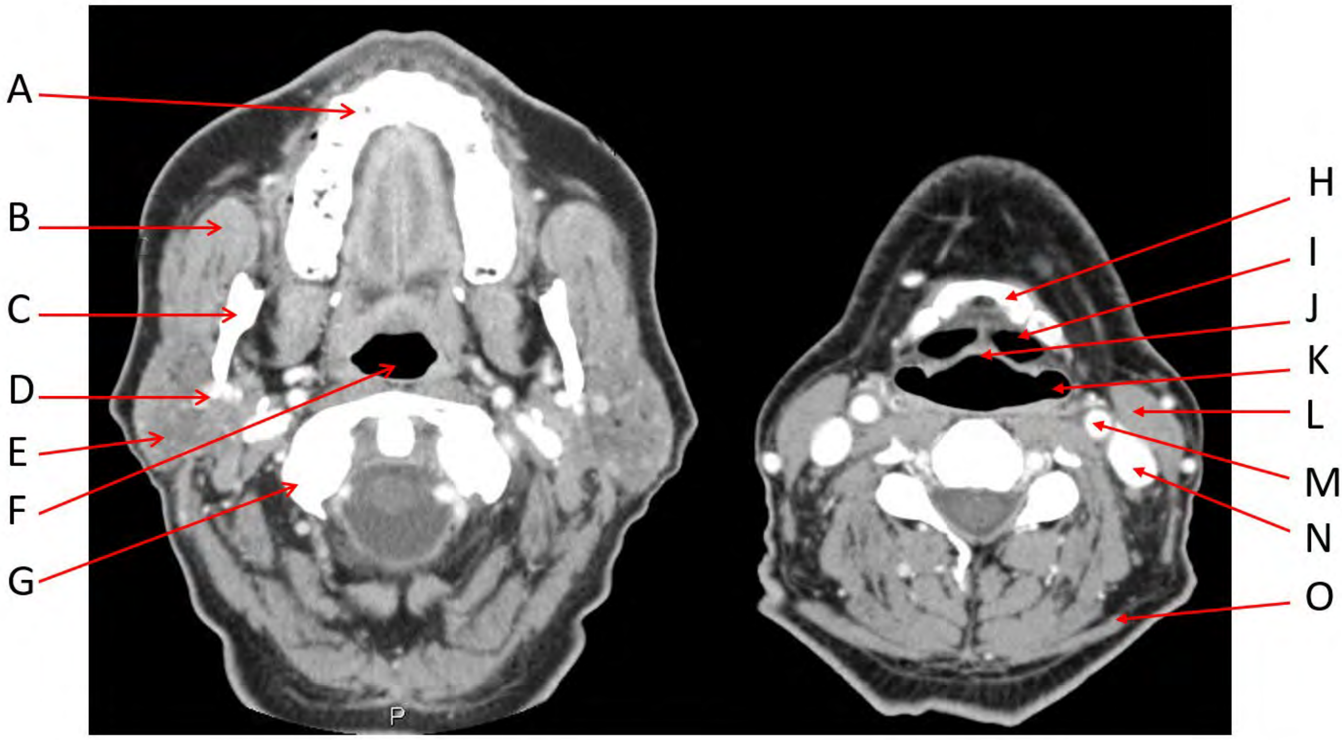


Question 10 cont

ANA

e. On the following axial CTs of the head and neck, name the structures labelled A to O. Indicate laterality if applicable. **(3 marks)**

(Answers are to be written in your answer booklet, not on the question paper)



Question 11

PHY

a. On the same set of axes, draw two (2) percentage depth dose curves comparing 6MV and 10MV photons for a 10 x 10 cm field in a water phantom. Include surface dose, depth of maximum dose (Dmax) and depth of 50% dose (D50). **(3 marks)**

b.

i. Using a table, compare a fixed source surface distance (SSD) radiation therapy technique to an isocentric radiation therapy technique with regards to the following characteristics for a multifield treatment: **(2 marks)**

- Source surface distance for each beam
- Speed of setup
- Set up accuracy
- Beam delivery time

ii. Describe two (2) advantages of prescribing to a fixed SSD technique rather than an isocentric technique for single field treatment. **(1 mark)**

c. Parallel opposed beams are the simplest technique when using a combination of fields.

i. Draw an isodose chart using equally weighted parallel opposed fields 6MV photons, 100cm SSD, 10 x 10 cm field, 30 cm separation prescribed to midplane. Include 50%, 90%, 100% and Dmax% isodose lines. **(3 marks)**

ii. How would your isodose chart differ if 10MV photons are used? **(1 mark)**

d. In practice, multifield radiation therapy can be delivered as a conformal or modulated techniques dependent on clinical requirements.

i. Describe the physical basis and the role of multi-leaf collimators (MLCs) on how dose is delivered for an IMRT beam compared to a traditional 3D conformal radiation beam. **(2 marks)**

ii. For IMRT plans, describe the process of inverse planning following patient data set acquisition to plan acceptance. **(3 marks)**

Question 12

RCB

a. Using a diagram, illustrate the phases of the cell cycle. **(2.5 marks)**

b. Briefly describe the cell activity that occurs in each cell cycle phase. **(2.5 marks)**

c. Identify three (3) key checkpoints in the cell cycle and name the associated protein complexes that regulate cell cycle progression at these checkpoints. **(3 marks)**

d. Several key proteins such as Rb protein, p53 and p21 prevent progression through the cell cycle at a checkpoint. Discuss in detail the mechanism by which these proteins act to regulate the cell cycle at this checkpoint. **(5 marks)**

e. Describe the relative radiosensitivity of cells in the different phases of the cell cycle and on the same set of labelled axes, draw cell survival curves for each of the phases of the cell cycle to illustrate this. **(2 marks)**