The Royal Australian and New Zealand College of Radiologists®

The Faculty of Radiation Oncology

Candidate Number: _____

FRANZCR Examination

Phase 1 Radiation Oncology

Paper 1

7 September 2018

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
  RCB = Radiation and Cancer Biology
  PHY = Radiation Oncology Physics

- All questions are worth 15 marks each. **The marks allocated to each sub-part of the questions are indicated in brackets.**
- 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.
- At the end of the examination please 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 the course of the facial nerve, starting from the brainstem until it exits the skull base. **(3 marks)**

b. Describe the course of the maxillary branch of the trigeminal nerve. **(3 marks)**

c. With the aid of a table, list the boundaries of the hypopharynx. **(2 marks)**

d. List the subparts of the hypopharynx and the lymphatic drainage for each subpart. **(3 marks)**

e. List the lymphatic drainage for a lesion located in the lateral part of the left oral tongue. **(1 mark)**

f. List the borders of the pterygopalatine fossa. **(3 marks)**

Question 2

PHY

a. Describe how an electron beam for clinical use is generated in a linear accelerator. (An annotated diagram may be used but is not required). **(3 marks)**

b.

i. For an electron beam, briefly explain how photon contamination occurs and include the magnitude of its effect on patient dose. **(1.5 marks)**

ii. List three potential sources of photon contamination. **(1 mark)**

c. For a 9 MeV electron beam with 10 cm x 10 cm field size at 100 cm source to surface distance (SSD) in water:

i. **Draw** a labelled percentage depth dose curve through the central axis. **(3 marks)**

Include values for:

- surface dose
- depth of maximum dose (Dmax),
- depth of 90% dose (R90),
- depth of 50% dose (R50) and
- practical range (Rp).

ii. **Draw** a labelled isodose chart, including the 100%, 90%, 50% and 10% isodose lines. **(3 marks)**

(Use the graph paper provided in your examination booklet)

d. In general for electron beams, describe the changes to the percentage depth dose curve with explanation of the physical principles when:

i. field size decreases. **(1.5 marks)**

ii. SSD increases. **(1 mark)**

iii. energy increases. **(1 mark)**

Question 3

RCB

a. Define the FIVE ‘Rs’ of radiobiology and using examples, comment on how each 'R' can influence cell survival or treatment delivery during a course of radiation treatment. **(5 marks)**

b. Define the α/β value and outline ONE limitation of the linear quadratic model. **(1 mark)**

c. For both acute and late reacting tissues, provide α/β values and comment on which parameter (α or β) dominates at low doses. **(1 mark)**

d. Altered fractionation schedules can be used to exploit variable radiobiological effects from ionising radiation between malignant and normal tissue.

i. What is altered fractionation and why is it used? **(1 mark)**

ii. Define and outline the rationale for TWO altered fractionation regimens. **(3 marks)**

e.

i. Define the term ‘double trouble’. **(1 mark)**

ii. For EACH of the categories of patient, tumour and treatment factors, list 3 factors that can impact the severity of side effects. **(3 marks)**

Question 4

ANA

a.

i. Describe the gross anatomy of the testes. **(1 mark)**

ii. List the macroscopic layers of the scrotum and testis. **(3 marks)**

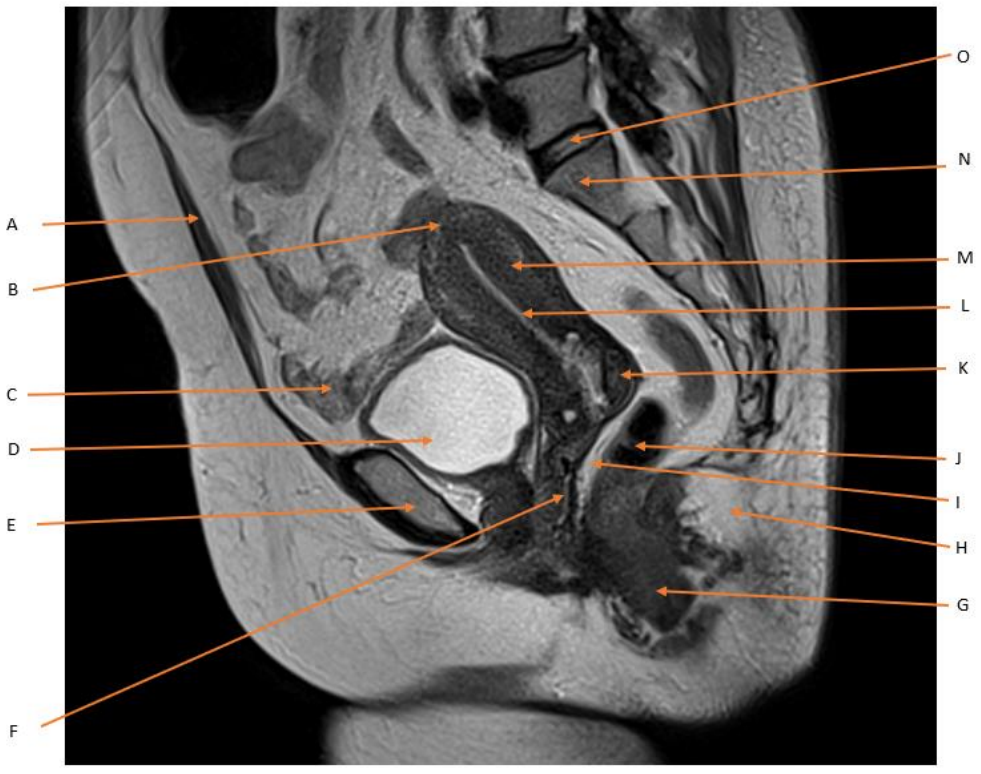
b. Describe the lymphatic drainage of the epididymis and right and left testes. **(3 marks)**

c. Draw a labelled diagram to demonstrate the gross anatomy of the vulva. **(3 marks)**

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

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

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



Question 5

PHY

In 2010, The New York Times reported multiple radiation dose-delivery errors that resulted in patient deaths.

Four systems that can be used to avoid and detect dose delivery errors are:

- Record and Verify Systems;
- Interlocks;
- Select and Confirm; and
- Imaging

a. Describe in detail each of the 4 systems above. **(4.5 marks)**
Include a specific example in your description of each system.

Most modern radiotherapy techniques rely on computer-controlled treatment delivery. This has reduced many of the random human-based errors but has introduced the potential for less common, but more severe, treatment delivery errors.

b. List 5 potential errors that can arise specifically at the time of radiation treatment. **(2 marks)**

c. Sievert is the standard international unit of radiation absorption. **(2 marks)**
Define in words and explain the rationale for its use in radiation protection.

d. Give millisievert (mSv) estimates for the following radiation exposure examples: **(2 marks)**

i. Average population background radiation exposure per year

ii. Chest X-ray

iii. Diagnostic CT Chest

iv. PET/CT

v. Maximum allowed occupation exposure of radiation workers per year (averaged over 5 years)

Question 5 cont

PHY cont

e. Brachytherapy is a treatment modality that can potentially expose staff to radiation.

i. Explain the three main principles used to minimise radiation exposure to staff. **(3 marks)**

A patient is receiving HDR brachytherapy for a locally advanced cervix carcinoma. Following completion of treatment, the radioactive source is unable to be remotely removed from the tandem and remains in the patient.

ii. Give three practical examples of how each of the above three principles could be implemented in this brachytherapy emergency situation. **(1.5 marks)**

Question 6

RCB

a. The primary cellular target of ionising radiation is DNA. **(2 marks)**

i. List the four (4) main types of DNA lesions caused by therapeutic ionising radiation.

ii. Define the terms:

ii.i Sublethal damage (SLD)

ii.ii Potentially lethal damage (PLD)

b. Describe the mechanism of action of the following protein complex units at sites of double-strand DNA breaks: **(4 marks)**

- ATM-MRN
- DNA-PKcs-KU

c.

i. Describe the processes of non-homologous end joining (NHEJ) and homologous recombination (HR). **(7 marks)**

ii. Compare the characteristics of these two DNA repair mechanisms. **(2 marks)**

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FRANZCR Examination

Phase 1 Radiation Oncology

Paper 2

7 September 2018

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
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Question 7

ANA

a. Well differentiated thyroid malignancy can treated with both radioactive iodine (^{131}I) and/or external beam radiation therapy in different circumstances.

i. Describe the gross anatomy of the thyroid gland. **(2 marks)**

ii. Use a labelled cross sectional axial diagram to demonstrate the relations of the thyroid gland at the level of the C7 vertebral body. **(4 marks)**

iii. Name the two major arteries that supply the thyroid gland and the name of the arteries from which each of these arise. **(1 mark)**

b. Name the following structures (including laterality where applicable):

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

i. **(3 marks)**
- A – G on the coronal MRI Brain image *(Image 1)*.

AND

- H – O on the axial MRI Brain image *(Image 2)*.

ii. **(3 marks)**
- A – O on the axial CT Upper Thorax image *(Image 3)*.

iii. **(2 marks)**
- A – E on the axial CT Mid Chest image *(Image 4)*.

AND

- F – J on the coronal CT Chest/Abdomen image *(Image 5)*.

Question 7 cont

ANA cont

Image 1

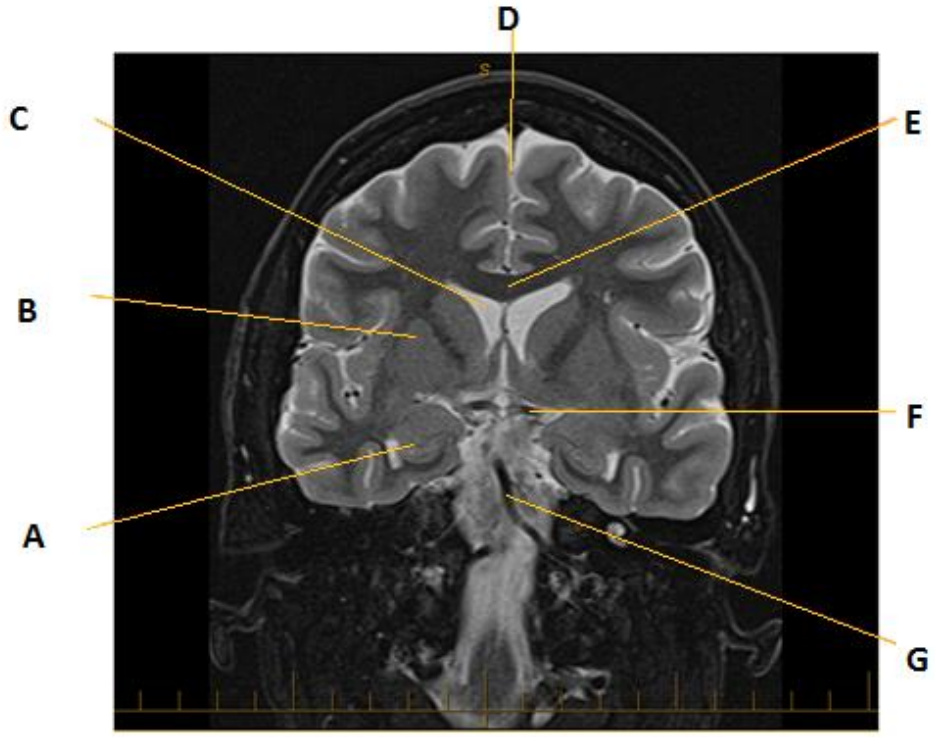
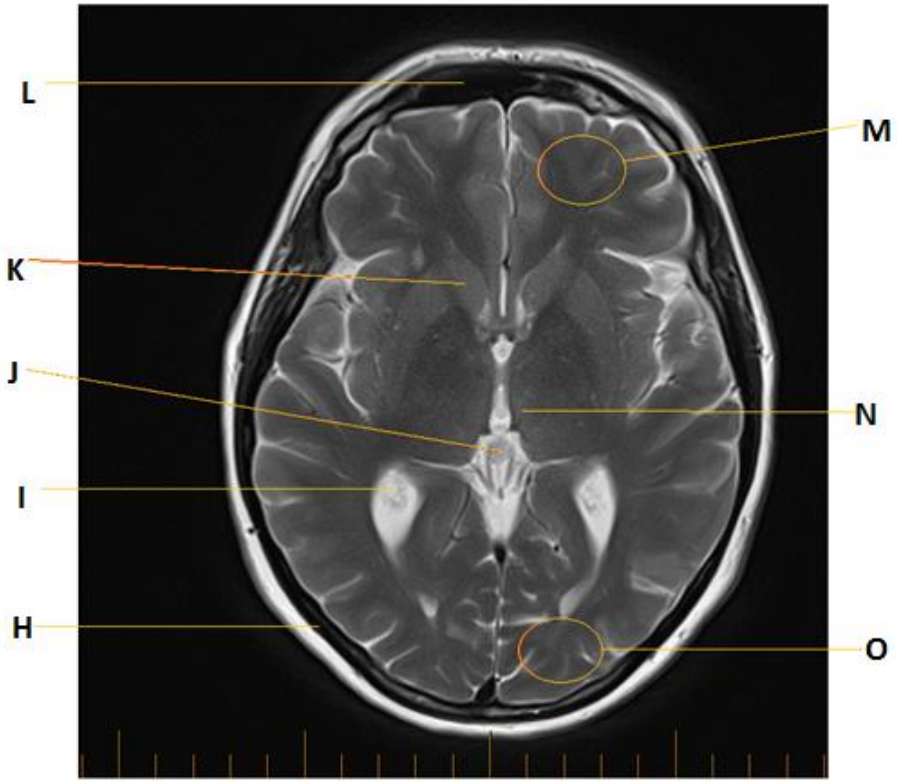


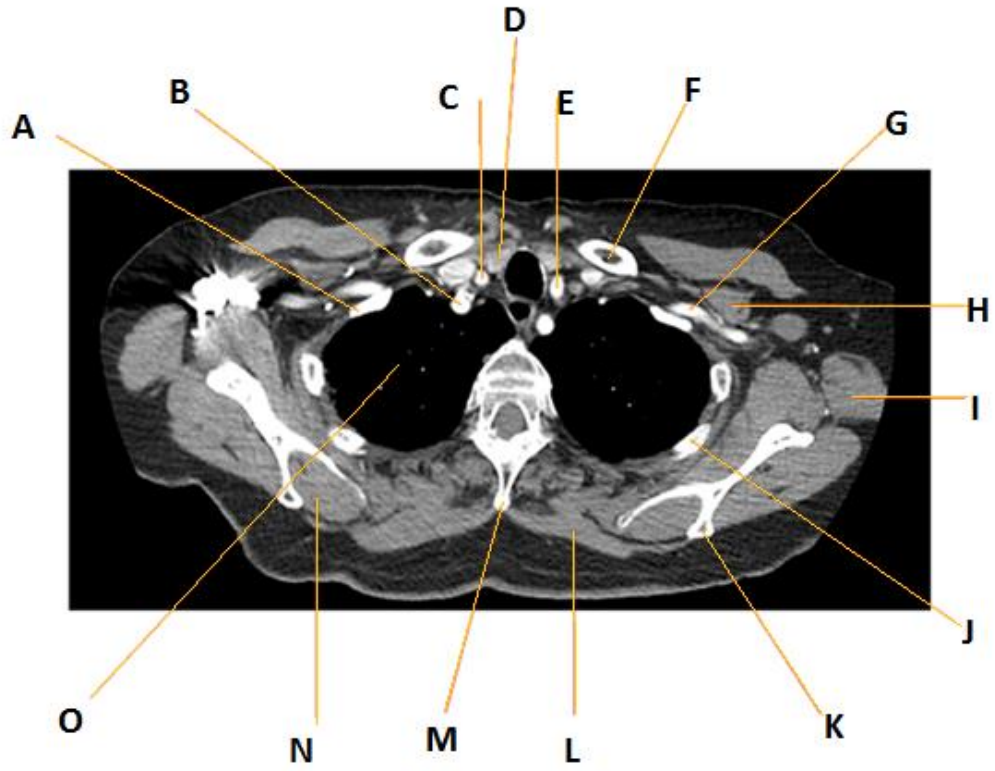
Image 2



Question 7 cont

ANA cont

Image 3



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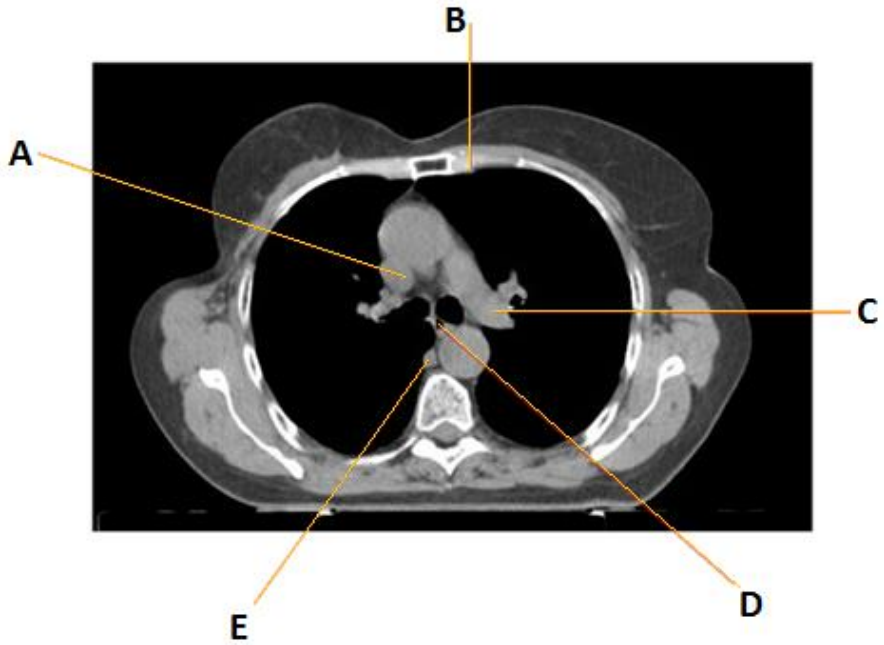
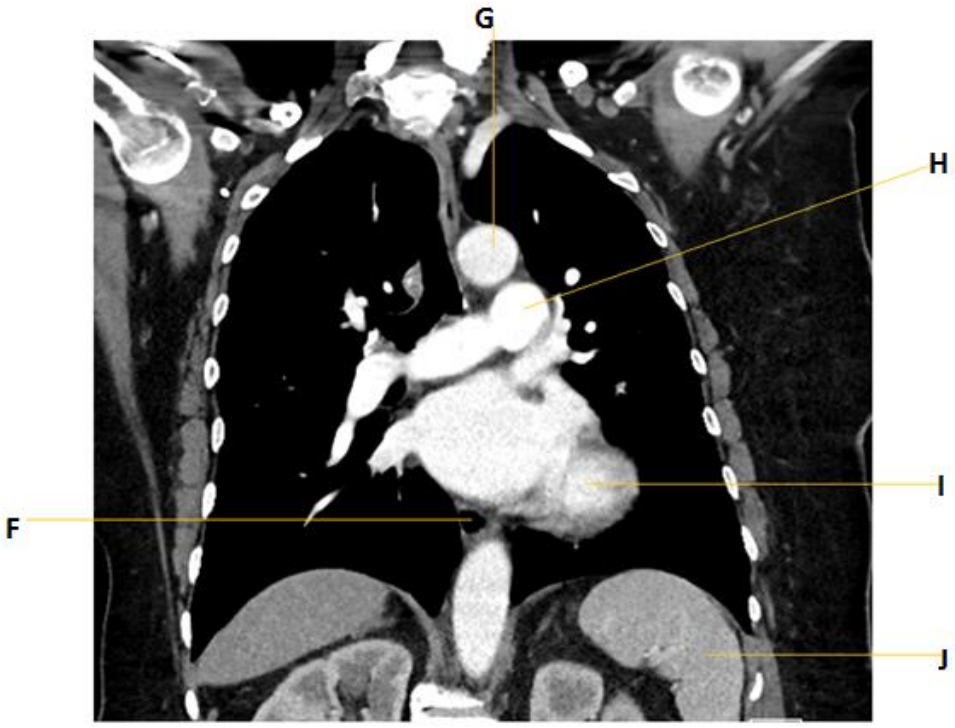


Question 7 cont

ANA cont

Image 5



Question 8

PHY

a.

i. **Draw** a labelled diagram illustrating central-axis percentage depth dose (PDD) curve for a 6 MV photon beam with 10 cm x 10 cm field size at 100 cm source to surface distance (SSD). **(4 marks)**

Include values for the following:

- Depth of maximum dose (Dmax)
- Percentage depth dose at 10cm depth
- Surface dose
- Dose build-up region

(Use the graph paper provided in your examination booklet)

ii. Provide an explanation for the dose build-up region. **(1 mark)**

b.

i. Describe how the PDD curve changes with higher energy beams and provide an explanation for these changes. In particular, describe what occurs to surface dose, Dmax and PDD at 10cm. **(2 marks)**

ii. Describe how the PDD curve changes with a larger field size and provide an explanation for these changes. **(1 mark)**

iii. Describe how the PDD curve changes with increases in SSD and provide an explanation for these changes. **(1 mark)**

Question 8 cont

PHY cont

c. The changes in percentage depth dose curve when there is tissue inhomogeneity depends on beam energy.

i. On one set of axes, draw (and label) in solid line, a percentage depth dose curve for a 100kV photon beam with 10 cm x 10 cm field size incident on a homogenous soft-tissue equivalent medium. On the same set of axes, draw (and label) in dotted line, a percentage depth dose curve by the same beam traversing through a composite phantom containing 2cm thick bone located at 4cm depth within the soft-tissue equivalent medium. **(2 marks)**

ii. On a separate set of axes, draw (and label) in solid line, a percentage depth dose curve for a 6MV photon beam with 10cm x 10 cm photon beam incident on a homogenous soft-tissue equivalent medium. On the same set of axes, draw (and label) in dotted-line, a percentage depth dose curve by the same beam traversing through a composite phantom containing 2cm thick bone located at 4cm depth within the soft-tissue equivalent medium. **(2 marks)**

iii. Provide an explanation for each of the curves above. **(2 marks)**

Question 9

RCB

a. Carcinogenic agents lead to genetic damage and are integral to the process of carcinogenesis.

i. List two classes of carcinogenic agents AND give an example of each. **(2 marks)**

ii. Briefly describe the mechanisms through which Human Papilloma Virus (HPV)-produced proteins cause carcinogenesis. **(2 marks)**

b.

i. Define the terms Oncogene and Tumour suppressor gene, giving an example of each. **(1 mark)**

ii. Briefly describe the multistep process of carcinogenesis. In your answer include the hallmarks of cancer. **(2 marks)**

c. A solid tumour with genetic aberrations does not have the capacity to enlarge unless it can induce angiogenesis. What is angiogenesis and describe two different mechanisms by which angiogenesis in tumour is promoted. **(4 marks)**

d. Tumour cells develop the ability to invade and form metastases.

i. Describe the key steps in the metastatic cascade. **(3 marks)**

ii. In general, why do tumour cells metastasise to particular distant sites? **(1 mark)**

Question 10

ANA

Contouring guidelines for pancreatic and gastric tumours are challenging, especially in the post-operative setting.

a. Describe the lymphatic drainage of the pancreas in relation to its subparts. **(3 marks)**

b. List two structures immediately inferior, posterior, to the right and left of the pancreas. Structures can be repeated if they lie for example both to the right and inferior. **(2 marks)**

c. Use an annotated sketch to show the relationship between the biliary tree, gall bladder, sphincter of Oddi (or Ampulla of Vater) and pancreatic duct of Wirsung. **(2 marks)**

d. In the lower gastrointestinal tract, patterns of disease spread are determined by organ anatomy and histology.

i. Describe the mucosal surface of the anal canal. **(1 mark)**

ii. Describe the blood supply of the anal canal. **(1 mark)**

iii. Describe the difference in histology of the anal canal and anal verge. **(1 mark)**

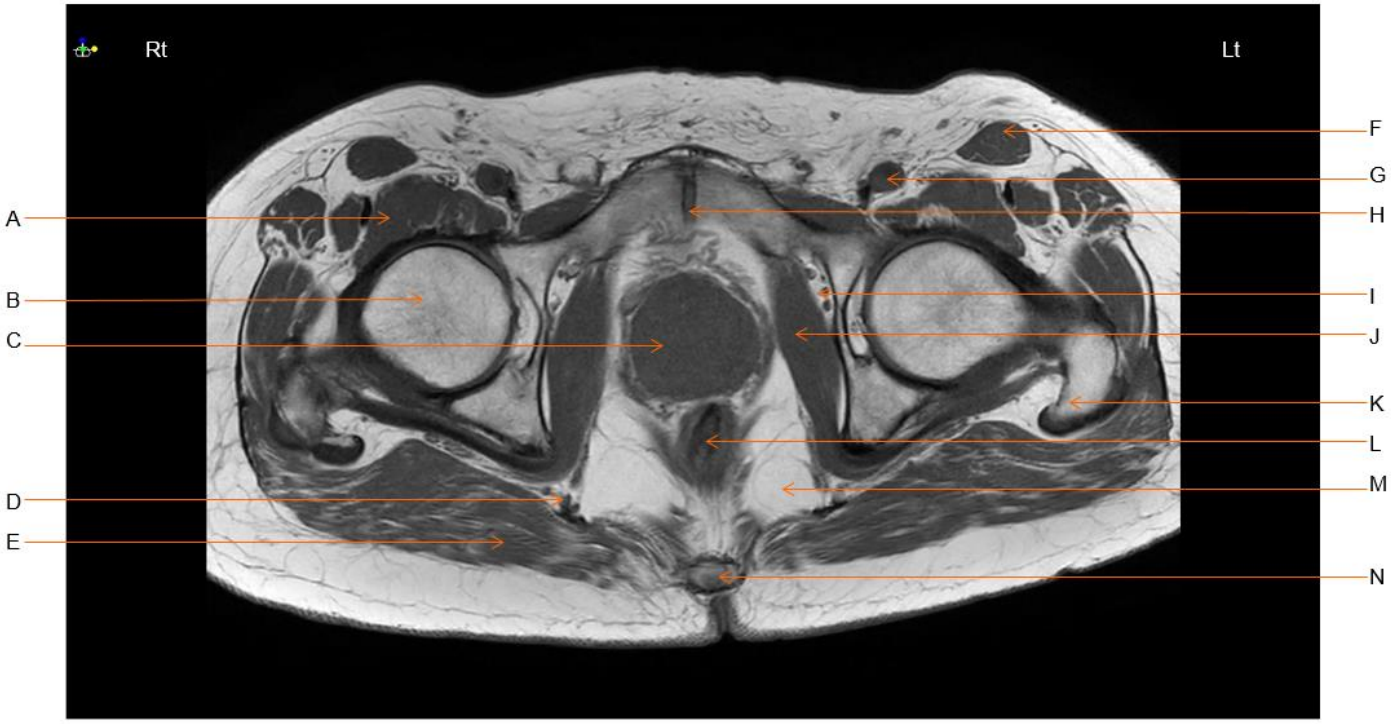
iv. Describe the lymphatic drainage at the anal canal. **(2 marks)**

e. Name the structures labelled A to N on the following MRI axial cross section of the male pelvis. Indicate laterality where applicable. **(3 marks)**

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

Question 10 cont

ANA cont



Question 11

PHY

a.

i. Describe in words the two processes that generate photons when electrons strike an x-ray target. **(2 marks)**

ii. Regarding the main process that generates therapeutic x-rays, describe how production relates to electron energy and the target material involved. **(2 marks)**

iii. Define in words 'efficiency of x-ray production'. **(1 mark)**

b. Describe the physical principles underlying the function of a free-air ionisation chamber. **(1 mark)**

c. For each of the following radiation measuring devices:

- Give a suitable scenario for its use.
- State two reasons for its application.
- State one limitation to consider.

i. Thimble (Farmer) chamber **(3 marks)**

ii. Thermoluminescent dosimeter **(3 marks)**

iii. Radiographic film **(3 marks)**

Question 12

RCB

a. Briefly outline the late effects that occur (at a morphological level) in normal blood vessels after radiation therapy. **(4 marks)**

The exposure of the entire human body to ionising radiation, particularly over a short time, can result in an acute radiation syndrome.

b. Describe the **four** phases of acute radiation syndrome and the specific side effects that will result from the body being exposed to increasing levels of radiation dose. You may find a table helpful in answering this question. **(4 marks)**

The data from atomic bomb survivors has provided information on the impact of a woman being exposed to ionising radiation during her pregnancy.

c. Describe, with reference to the stage of pregnancy and the dose of radiation exposure, the effect ionising radiation could have on an embryo or foetus. **(3 marks)**

Exposure to diagnostic or therapeutic radiation can result in a radiation induced malignancy in the years after radiation exposure.

d. Discuss the model used as the basis of radiation protection policy to predict the development of a radiation induced malignancy. Include in your answer an explanation of stochastic and deterministic effects. **(4 marks)**