The Royal Australian and New Zealand College of Radiologists®

The Faculty of Radiation Oncology

Candidate Number: _____

FRANZCR Examination
Phase 1 Radiation Oncology

Paper 1

10 September 2021

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. **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.
- 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 anatomical boundaries of the axilla and list its contents. **(3 marks)**

b. Describe the lymphatic drainage of the upper limb. **(3 marks)**

c.

i. Using a well-labelled diagram, illustrate the lobar structure of the lungs and fissures. **(2 marks)**

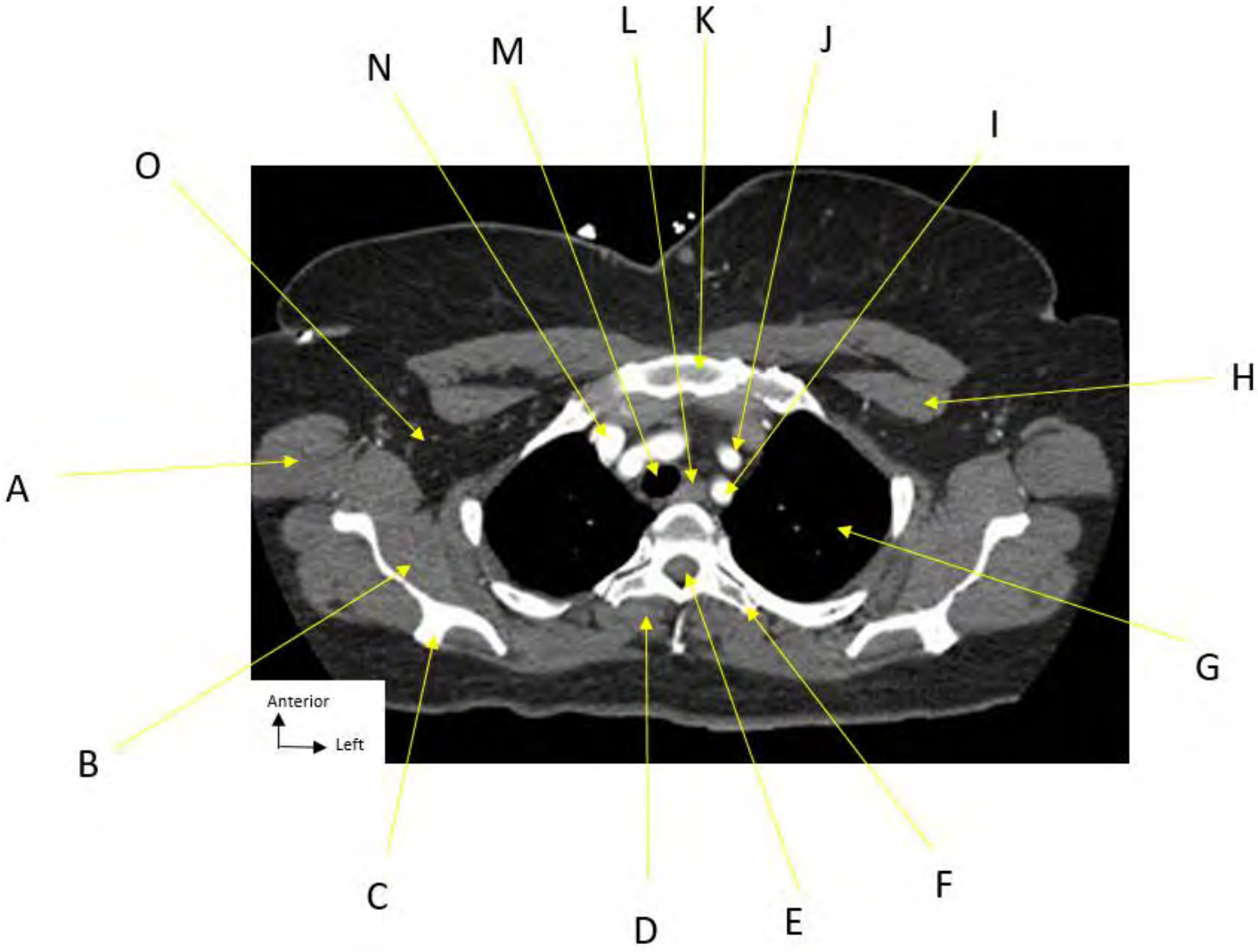
ii. List the structures that can be found along the medial surface of the left lung. **(1 mark)**

iii. Briefly describe the blood supply to the lung. **(1 mark)**

Question 1 (Continued)

ANA

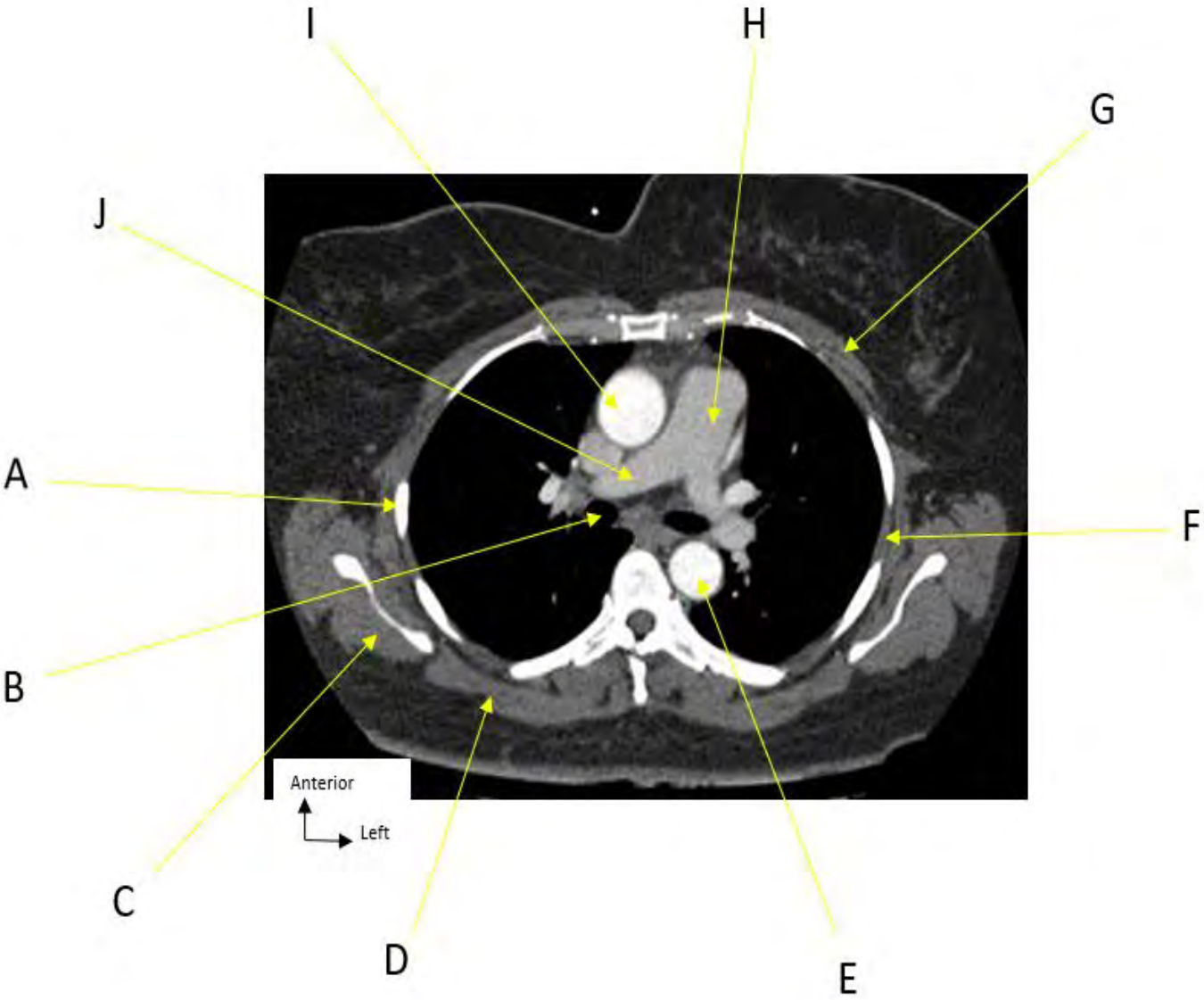
d. Name the structures labelled A to O on the axial CT slice below through the upper thorax and indicate laterality where applicable. **(3 marks)**



Question 1 (Continued)

ANA

e. Name the structures labelled A to J on the axial CT slice below through the mid thorax and indicate laterality where applicable. **(2 marks)**



Question 2

PHY

a.

i. Define penumbra. **(0.5 marks)**

ii. Define physical penumbra. Choose one of the subtypes of a physical penumbra and briefly explain it. **(1.5 marks)**

iii. Describe and briefly explain how an increase in source skin distance (SSD) from 100 cm to 120 cm would affect physical penumbra for a 10 x 10 cm 6 MV photon beam field incident on a water phantom. **(2 marks)**

b. Modern linear accelerators can offer a delivery technique known as "FFF" (Flattening Filter Free). **(4 marks)**

On a single labelled graph for a 10 x 10 cm field at 10 cm depth in water, draw the following two beam profiles:

- a conventional 6 MV photon beam; and
- a FFF 6 MV photon beam.

Comment on the differences between the dose rate for the two beams.

c.

i. Draw isodose curves in a plane perpendicular to the junction line between abutting photon and electron fields in a water phantom for a 9 MeV electron beam 10 x 10 cm in size and a standard 6 MV photon beam 10 x 10 cm field at 100 cm SSD. **(4 marks)**

Explain the potential dosimetric implications.

ii. What would happen to hot and cold spots with an increase in SSD of the electron field? **(2 marks)**

iii. How would a change from 9 MeV to 18 MeV electron beam affect the hot spot? **(1 mark)**

Question 3

RCB

a.

i. Using a diagram, outline the phases of the cell cycle and their approximate duration in a typical rapidly proliferating human cell with a total cell cycle time of 24 hours. **(2 marks)**

ii. In a table, list four cyclins and the cyclin dependent kinases that are associated within the cell cycle. **(3 marks)**

b.

i. Briefly outline what is the purpose of the: **(1.5 marks)**

- G1/S phase cell cycle checkpoint?
- S phase cell cycle checkpoint?
- G2 phase checkpoint?

ii. List three possible outcomes after a cell arrests at a cell cycle checkpoint. **(1.5 marks)**

c. In detail, outline the steps that occur at the G1/S phase cell cycle checkpoint. **(5 marks)**
Include in your answer:

- the specific interactions that take place that enable a cell to proceed on to the next phase of the cell cycle.
- how inhibition of progression through the G1/S phase checkpoint occurs.

d. The cell cycle phases have different levels of radiosensitivity. On one set of labelled axes, draw a graph that illustrates cell survival curves during different phases of the cell cycle. Identify the most radiosensitive and most radioresistant phases of the cell cycle. **(2 marks)**

Question 4

ANA

a.

i. What structure produces cerebrospinal fluid (CSF) and where is it located? **(1 mark)**

ii. Name the ventricles of the brain and their connecting foramina. **(1.5 marks)**

b.

i. Name the components of the brainstem. **(1 mark)**

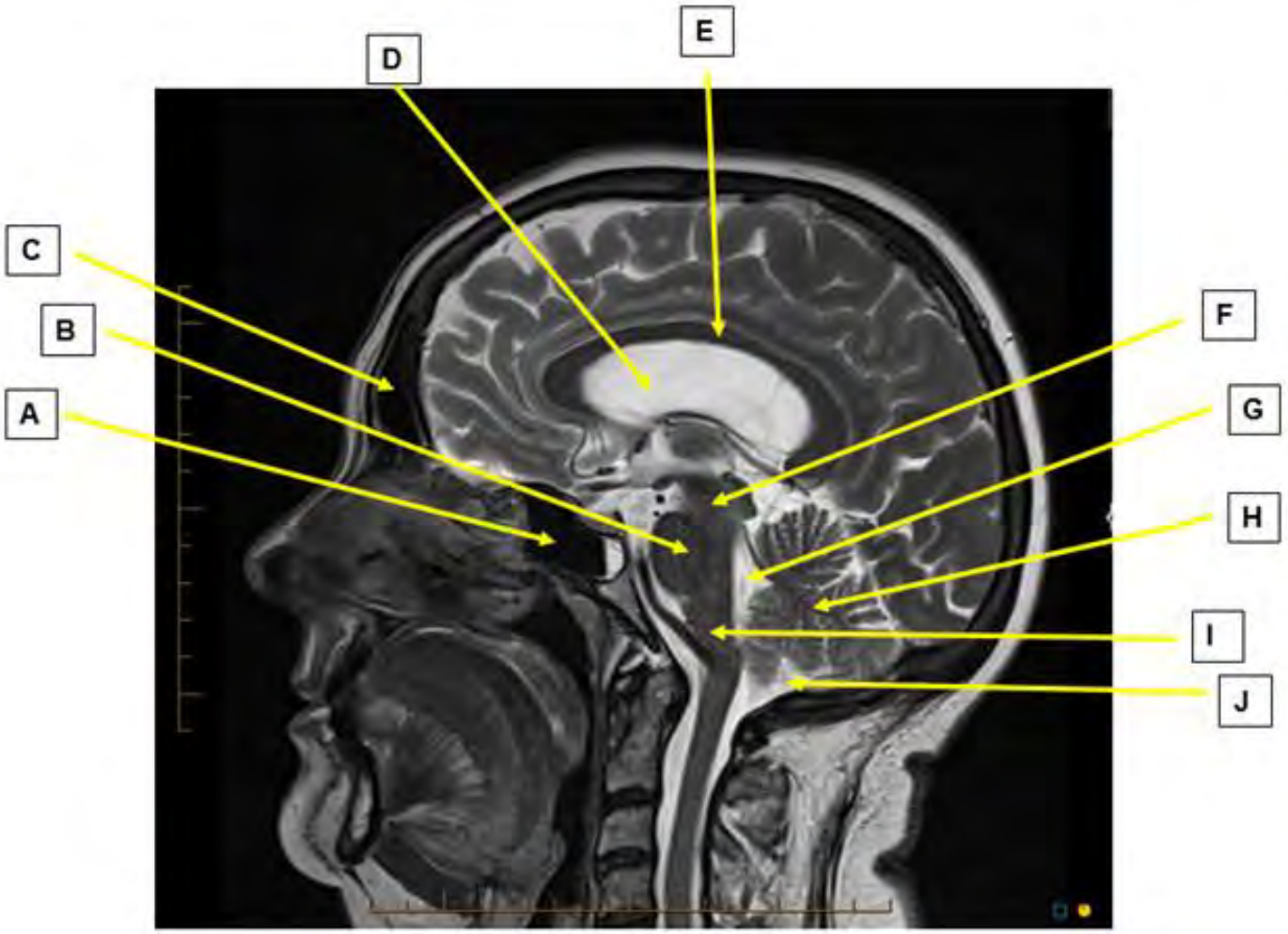
ii. Where does the vagus nerve (CN X) originate from? **(0.5 marks)**

iii. Name the major branches of the vagus nerve. **(2 marks)**

Question 4 (Continued)

ANA

c. Name the structures A to J on the sagittal MRI brain below. **(2 marks)**



d. List the foramina from which each cranial nerve exits the skull (and its corresponding cranial nerve/s). **(2.5 marks)**

e.

i. Describe the course of the oculomotor nerve. **(2.5 marks)**

ii. List the structures that are innervated by the oculomotor nerve. **(2 marks)**

Question 5

PHY

a. With regards to external beam radiation therapy for intact prostate malignancy, compare the two image guidance techniques of cone beam computed tomography (CBCT) with soft tissue match and kV planar imaging with fiducial match in terms of:

i. Physical principles. **(2 marks)**

ii. Clinical advantages. **(2 marks)**

b. With regards to external beam radiation therapy for intact prostate malignancy in a patient with a metal hip prosthesis, explain the physical principles and potential clinical impact of the prosthesis on:

i. Acquisition of CT simulation images. **(1.5 marks)**

Give one example of how the impact of the prosthesis on accuracy can be minimised.

ii. Planning of megavoltage treatment by the treatment planning system. **(1.5 marks)**

c. When a patient is being set up for treatment, list four methods by which position and internal anatomy may be verified prior to delivery. **(2 marks)**

d. Each of the following systems are used to prevent radiation accidents. For each system:

- describe the operation, and
- give one example of a potential error that it is designed to prevent.

i. Record and verify **(2 marks)**

ii. Machine interlocks **(2 marks)**

iii. Door interlocks **(2 marks)**

Question 6

RCB

Combination radiation therapy and cytotoxic chemotherapy or surgery provides better therapeutic ratio than radiation therapy alone for a number of malignancies.

a. Briefly describe the concept of ‘spatial co-operation’. Include two examples of how this concept is applied with different objectives. **(3 marks)**

b. Describe four molecular mechanisms by which systemic therapy can enhance the cytotoxic effect of radiation therapy (i.e. give a synergistic, rather than an additive effect). **(4 marks)**

c. List two disadvantages of concurrent chemoradiation and two disadvantages of sequential chemotherapy and radiation therapy. **(2 marks)**

d. Describe the radiobiological advantages and disadvantages of pre-operative radiation therapy and post-operative radiation therapy. **(6 marks)**

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Paper 2

10 September 2021

2:00pm

Time Allowed: 2.5 Hours

INSTRUCTIONS

- There are a total of SIX questions numbered 7 – 12.
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Question 7

ANA

a.

i. Name the three subsites of the larynx and describe the superior and inferior boundaries of each subsite. **(2 marks)**

ii. List the individual components of each subsite of the larynx. **(1 mark)**

b.

i. List the subsites of the oropharynx. **(1 mark)**

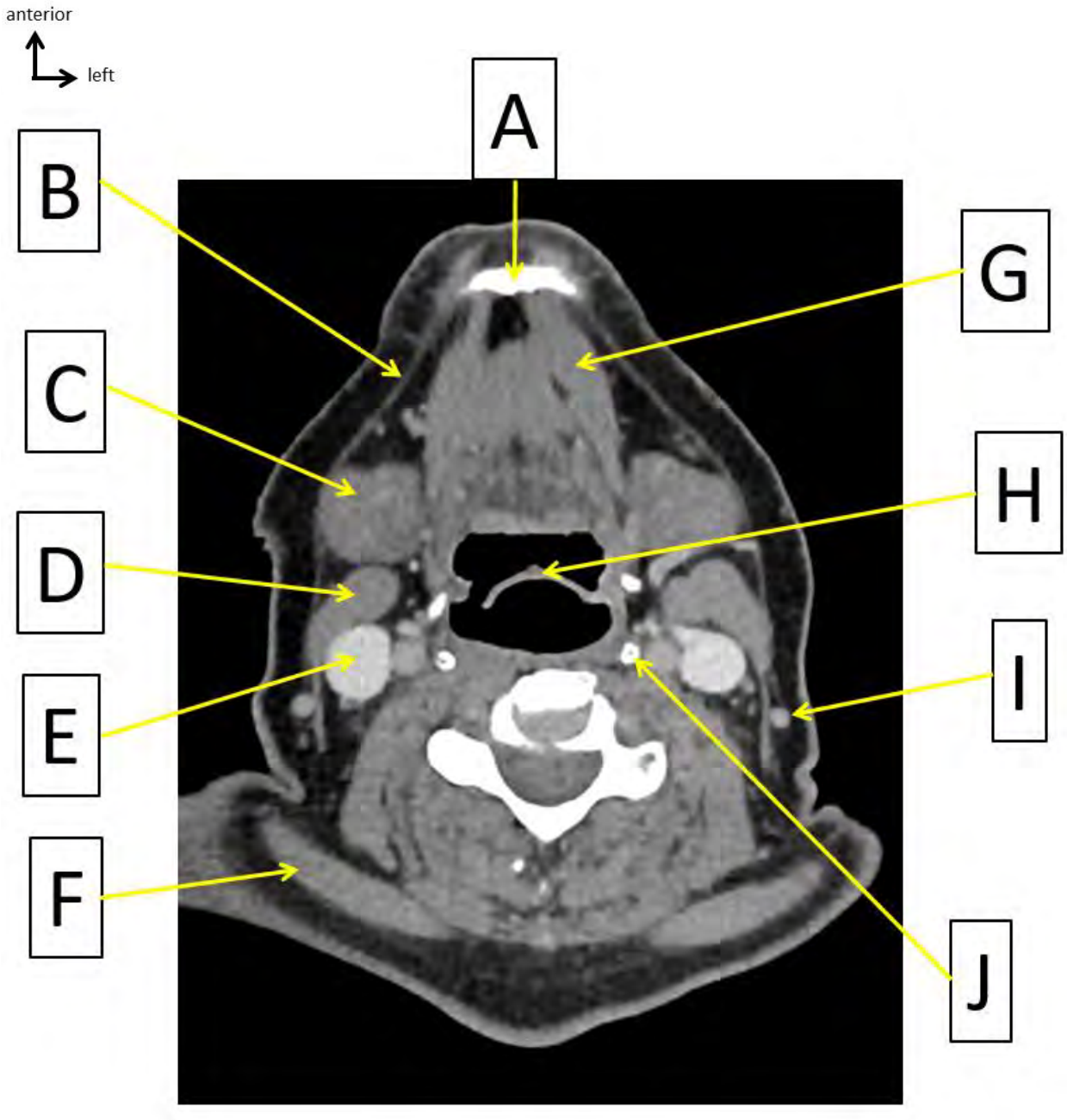
ii. Describe the lymphatic drainage of the oropharynx according to anatomical subsite, including major nodal stations. **(3 marks)**

c. List the boundaries and contents of the cavernous sinus. **(4 marks)**

Question 7 (Continued)

ANA

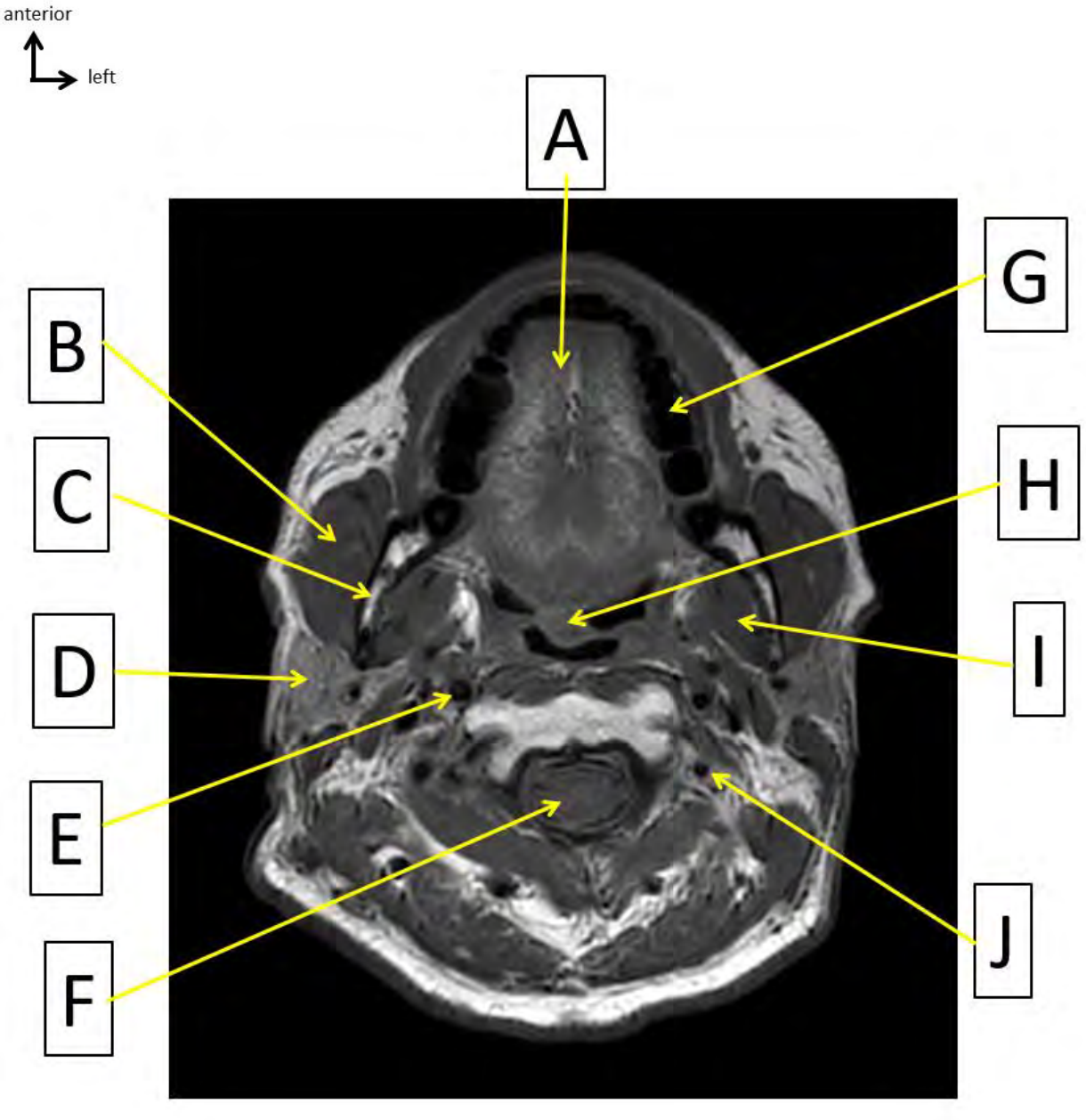
d. Name the structures labelled A to J on the axial CT slice below through the head and neck. Indicate laterality where applicable. **(2 marks)**



Question 7 (Continued)

ANA

e. Name the structures labelled A to J on the axial MRI slice below through the head and neck. Indicate laterality where applicable. **(2 marks)**



Question 8

PHY

Unsealed sources such as Iodine-131, Yttrium-90 and Samarium-153 are treatment options for patients with some malignant and non-malignant indications.

a. Draw a table to illustrate the differences between Iodine-131, Yttrium-90, and Samarium-153 in terms of types of: **(4 marks)**

- radiation emitted
- maximal energy of each type of radiation
- physical half-life
- an example of its use clinically
- the estimated length of stay in hospital after treatment until safe for discharge for radiation protection purposes.

b. In relation to the radioisotope Iodine-131, define physical, biological and effective half-life. **(3 marks)**

c. In relation to the radioisotope Iodine-131, explain the differences between uptake, distribution and elimination with specific examples. **(4 marks)**

d. Define briefly Medical Internal Radiation Dose (MIRD). **(1 mark)**

e. Describe two factors that influence MIRD. **(2 marks)**

f. Briefly explain how MIRD is calculated. **(1 mark)**

Question 9

RCB

a.

i. Define the terms “oncogene” and “tumour suppressor gene” and whether one or both alleles must be affected for cancer to develop. **(2 marks)**

ii. List three examples of oncogenes and three examples of tumour suppressor genes. For each gene listed, include one example of the cancer type in which they play a causative role. **(3 marks)**

iii. List and describe three mechanisms of proto-oncogene activation. **(3 marks)**

b. Blood supply, through angiogenesis, is critical for a cancer to grow and spread.

i. Compare and contrast the vasculature (i.e. blood vessels) found in non-malignant versus malignant tissues in terms of blood flow, structure and cell type. Answers can be presented in a table. **(3 marks)**

ii.

a. Name the key regulator of angiogenesis within malignant tissue and how it is upregulated. **(0.5 marks)**

b. List two inhibitors of angiogenesis. **(0.5 marks)**

iii. Outline the steps involved in the metastatic cascade. A diagram may be used for illustration. **(3 marks)**

Question 10

ANA

a. For rectal cancers, the extent of mural invasion and the presence of extramural venous invasion have prognostic significance.

i. List the microscopic layers of the rectum from innermost to outermost. **(1 mark)**

ii. Describe the venous drainage of the rectum. **(2 marks)**

b. Pelvic radiation therapy is commonly used in the management of uterine cancers to reduce the risk of primary and pelvic lymph node recurrence.

i. Describe the lymphatic drainage of the uterus. **(2 marks)**

Uterine position varies with bladder filling which can impact on radiation therapy planning and treatment.

ii. Use well-labelled diagrams in the sagittal plane to describe the two version and two flexion positions of the uterus. **(2 marks)**

c.

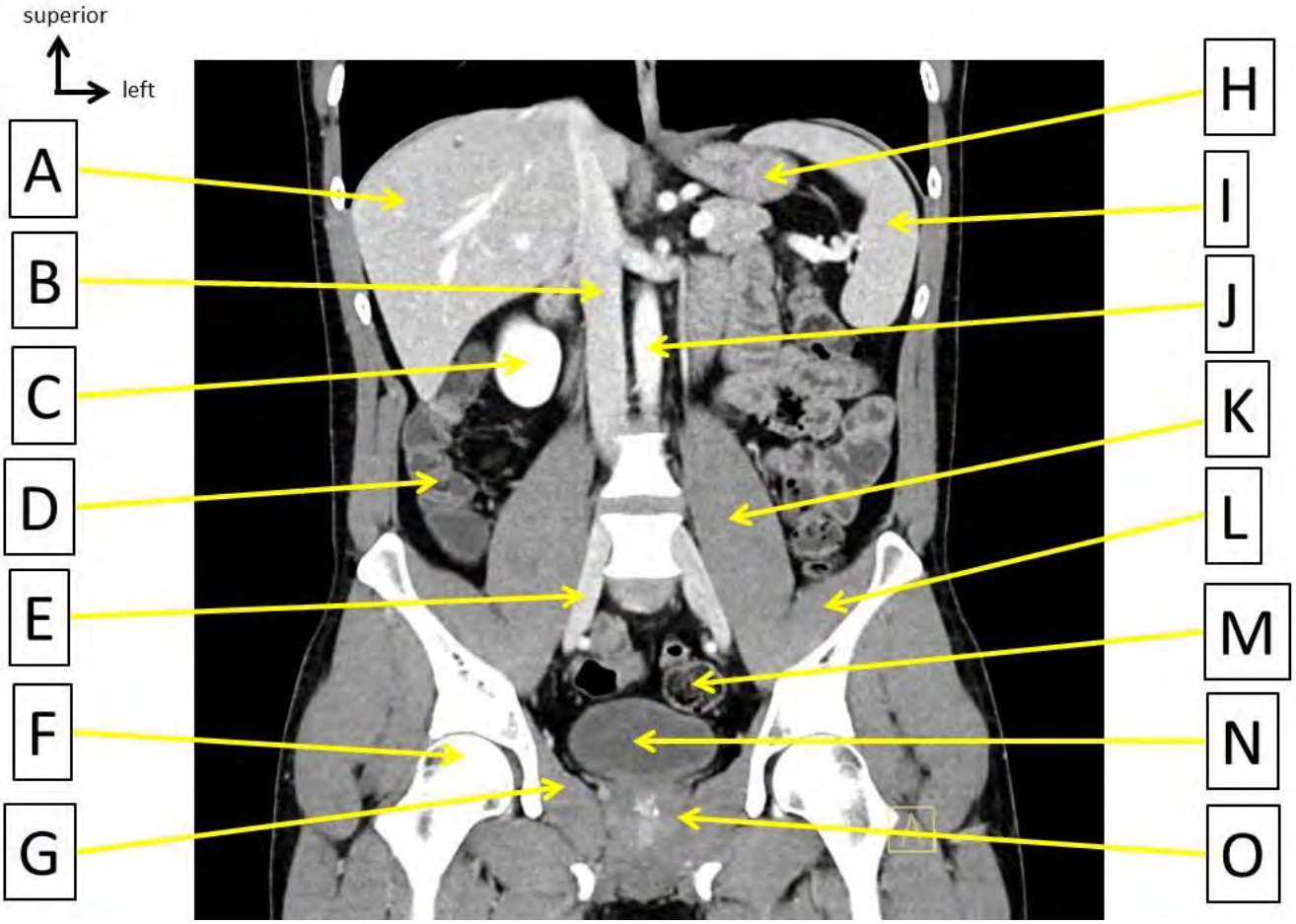
i. List the relations of the left and right adrenal glands. **(3 marks)**

ii. Describe the macroscopic structure of the left and right adrenal glands. **(2 marks)**

Question 10 (Continued)

ANA

d. Name the structures labelled A to O on the coronal post-contrast CT slice of the male abdomen and pelvis below. Indicate laterality where applicable. **(3 marks)**



Question 11

PHY

a. A patient is planned for high dose radiation therapy to a single target in the chest using Volumetric Modulated Arc Therapy (VMAT). The dosimetry is calculated, approved and then sent for Patient-Specific Quality Assurance (PSQA) before treatment begins. **(1 mark)**

Briefly explain why PSQA is required when using modulated radiation therapy techniques such as VMAT.

b. In general, list at least three different pieces of information that might be helpful to assess at PSQA. **(2 marks)**

c. For each of the following different types of phantoms, give one advantage and one disadvantage associated with their use. Do not use the same reason more than once. **(3 marks)**

i. Water phantom

ii. Perspex slab phantom

iii. Anthropomorphic phantom

d. Describe the physics principles underlying the function of a Geiger-Müller counter. **(3 marks)**

Question 11 (Continued)

PHY

e. For each of the following radiation measuring devices, give a suitable example of their use in the radiation oncology department and a reason for your answer. **(6 marks)**

i. Geiger-Müller counter

ii. Thimble (Farmer) chamber

iii. Thermoluminescence diode chips

Question 12

RCB

a. Define the FIVE ‘Rs’ of fractionation and describe how each 'R' can impact on a course of radiation treatment. **(5 marks)**

b. Define the terms “hyperfractionation” and “accelerated radiation therapy”. **(6 marks)**

For each term, outline their radiobiological advantages and disadvantages.

c. Briefly outline the radiobiological rationale for the use of hypofractionated radiation therapy in the palliative treatment of metastatic prostate cancer. **(2 marks)**

d. What is the evidence for the existence of repopulation in human tumours? **(2 marks)**