QUESTION WORKBOOK

X-rays and CT scanning

Medical physics · Year 13

AQA 3.10.5.1, 3.10.5.2, 3.10.5.3, 3.10.5.4 · CIE 24.2.1, 24.2.2, 24.2.3, 24.2.4
OCR A 6.5.1(a), 6.5.1(b), 6.5.1(c), 6.5.1(d), 6.5.1(e), 6.5.1(f), 6.5.1(g)

19 questions · 53 marks

NAVY SCREEN EDITION

SECTION A · Warm-up

A1 Describe how X-rays are produced in an X-ray tube. [3]

A2 An X-ray tube operates at 65 kV. Calculate the maximum energy of a photon in the beam. [2]

A3 State the equation for the attenuation of X-rays passing through matter, defining each symbol. [2]

A4 State why the inside of an X-ray tube is evacuated. [1]

A5 The photons leaving an X-ray tube have a spread of energies below the maximum eV. Explain why photons of lower energy are present. [2]

SECTION B · Standard

B1 Calculate the minimum wavelength of X-rays from a tube operating at 100 kV. [3]

B2 Soft tissue has an attenuation coefficient of 0.21 cm^{-1} for one diagnostic beam. Calculate the fraction of the incident intensity transmitted through 4.0 cm of this tissue. [3]

B3 An operator increases the tube voltage. Separately, the operator increases the tube current. State the effect of each change on the X-ray beam. [2]

B4 The attenuation coefficient of bone for a certain beam is 0.60 cm^{-1}. Calculate the half-value thickness of bone, the thickness that halves the beam intensity. [3]

B5 Explain why bone shows clearly on a plain X-ray image while two neighbouring soft tissues often do not, and how a contrast medium helps. [3]

B6 A beam of X-rays passes through 2.5 cm of muscle. The transmitted intensity is 0.35 of the incident intensity. Determine the attenuation coefficient of muscle for this beam. [3]

B7 Modern radiography records the transmitted beam with a digital flat-panel detector rather than photographic film. State two advantages of the digital detector. [2]

B8 Pair production is one mechanism by which photons are absorbed in matter. State the minimum photon energy for pair production, and explain why it plays no part in imaging with a 90 kV tube. [2]

SECTION C · Stretch

C1 A beam passes through soft tissue with $\mu = 0.35\ \text{cm}^{-1}$. Calculate the thickness that reduces the intensity to one tenth of its incident value. [3]

C2 Explain the principle of CT scanning, and state one advantage and one disadvantage of a CT scan compared with a plain X-ray image. [4]

C3 An X-ray tube runs at 120 kV with a beam current of 2.0 mA. Calculate the maximum photon energy, and the number of electrons striking the target each second. [3]

C4 Most of the energy delivered to the target of an X-ray tube does not become X-rays. State what it becomes, and explain two design features of the anode that deal with it. [3]

C5 A patient's abdomen presents a 5.0 cm path to an X-ray beam. Soft tissue along this path has attenuation coefficient 0.20 cm^{-1}. Before the gut is imaged, the patient swallows a barium meal that fills a 1.0 cm section of the path with a compound of attenuation coefficient 3.0 cm^{-1}. Deduce, with calculations, whether the barium meal gives the gut useful contrast against the surrounding tissue.

[4]

C6 Describe the mechanisms by which photons are removed from a diagnostic X-ray beam as it passes through the body, and explain which mechanism gives bone its contrast. [5]

