

24.2 Production and use of X-rays

Name: _____ Class: _____ Date: _____

Total: 25 marks

KEY WORDS contrast 对比度 • x-ray tube X 射线管 • electron 电子 • target 靶 • cathode 阴极

Objective

Build the skills to answer exam questions on **X-rays** in medicine.

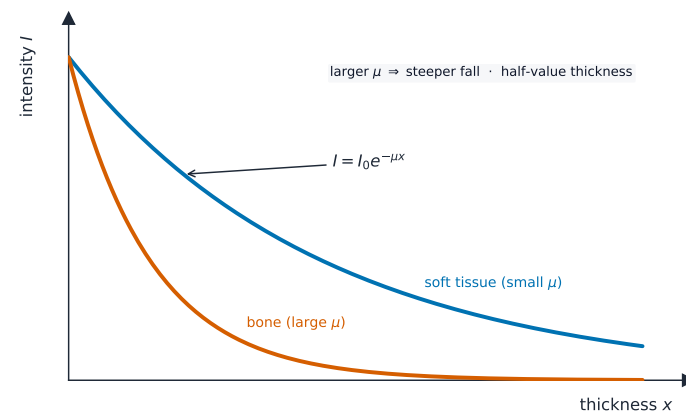
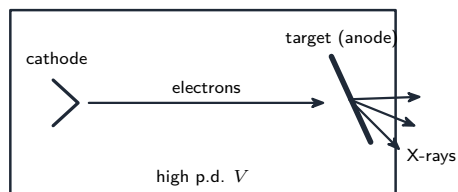
You must be able to:

- explain X-ray production and find the **minimum wavelength**
- use the attenuation $I = I_0 e^{-\mu x}$ and **contrast**
- describe **CT scanning**

1 Worked examples

Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

■ Production



X-ray attenuation through tissue

Electrons from a heated **cathode** are accelerated by a high p.d. V onto a metal **target**. The most energetic photon has the full electron KE:

$$hf_{\max} = eV, \quad \lambda_{\min} = \frac{hc}{eV}.$$

■ Imaging

X-rays are **attenuated** as $I = I_0 e^{-\mu x}$; bone (high μ) absorbs more than soft tissue, giving **contrast**. **CT scanning** combines many X-ray images from different angles into a 2D slice, then stacks slices into a **3D** image.

2 Practice

Now apply the methods above.

2.1 Describe how **X-rays** are produced in an X-ray tube. [2]2.2 Write the equation for the **minimum wavelength** of X-rays. [1]

2.3 Write the equation for the **attenuation** of X-rays. [1]

2.4 State what is meant by **contrast** in an X-ray image. [1]

3 Exam-style questions

3.1 The **minimum wavelength** of the X-rays from a tube depends on: [1]

- | | |
|---|---|
| A | B |
| C | D |
- A the target metal
B the accelerating p.d.
C the tube current
D the tube length

3.2 An X-ray tube uses an accelerating p.d. of 50 kV. Calculate the **minimum wavelength** of the X-rays. [3]

3.3 Describe how a **CT scan** produces a 3D image of the body. [3]

3.4 An X-ray tube accelerates electrons through a potential difference of 5.80 kV onto a metal target. Take $h = 6.63 \times 10^{-34}$ J s, $c = 3.00 \times 10^8$ m s⁻¹ and $e = 1.60 \times 10^{-19}$ C.

(a) **Name** the two processes by which X-rays are produced at the target, and **state** which gives the continuous part of the spectrum. [3]

(b) **Explain** why the spectrum has a sharp **minimum** wavelength. [2]

(c) **Determine** that minimum wavelength. [3]

(d) The X-rays pass through a medium of attenuation coefficient 1.4 cm^{-1} . **Determine** the percentage of the X-ray energy **absorbed** by a thickness of 2.8 cm. [3]

(e) **Explain** why a contrast medium such as barium is given to a patient before imaging soft tissue. [2]