

M1.(a) (i) Provide aperture through which X-rays may pass, stopping others ✓

Alternatives: provides collimation; produces narrow beam of X-rays; protects areas of the body not being scanned

1

(ii) Filters out (most) low energy photons (but allows high energy photons to pass through) ✓

*Allow 'soft' or underpower' for low energy
Allow only high energy photons pass through*

1

(b) $I / I_0 = 0.917$ ✓

$$\ln(0.917) = -\mu \times 2.7 \times 10^{-3} \quad \checkmark$$

$$\mu = 32.1 \quad \checkmark$$

$$\mu_m = \mu / 2700 = 0.012 \quad \checkmark$$

$$\text{m}^2 \text{ kg}^{-1} \quad \checkmark$$

If 0.083 or 91.7 used, final 3 calc marks can be given

If 0.83 or 8.3 or 9.17 used, final 2 calc marks can be given

Unit mark is independent mark

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M2. (i) thickness needed to reduce intensity by half (1)
for X-rays of specific energy (1)

$$(ii) \quad \mu = \frac{\ln 2}{x} \quad (1)$$

$$= 58 \text{ m}^{-1} (1) \quad (57.8 \text{ m}^{-1})$$

(iii) (use of $I = I_0 e^{-\mu x}$ gives) $0.05 = e^{-57.8x}$ (1)

$$x = 0.052 \text{ m (or 52 mm)} (1) \quad (51.8 \text{ mm})$$

(allow C.E. for value of μ from (ii))

[6]

- M3.** (a) for clear image need large difference in densities between part being investigated and parts around it **(1)**
 when this is not natural, add material to part under investigation **(1)**
 which has high density to provide good attenuation of X-rays **(1)**
 barium meal use barium sulphate **(1)**

max 3

- (b) $\mu (= \rho\mu_m) = 2700 - 0.012 = 32.4$ **(1)**
 (use of $I = I_0 e^{-\mu x}$ gives) $1.2 \times 10^{-2} = 3.2 \times 10^{-2} \times e^{-32.4x}$ **(1)**
 (allow C.E. for value of μ)
 $x = 0.03(0)$ m **(1)**

3

[6]

- M4.(a)** 1: vacuum / evacuated (tube) **(1)**
 2: lead (lined shield) **(1)**
 3: electrons (beam) **(1)**

3

- (b) (i) heat is spread over a greater volume / area / section **(1)**
 thus allows more energetic X-rays to be produced
 [or allows X-rays to be generated for longer] **(1)**
 (ii) (bevelled edge) gives larger target area **(1)**
 but small source area (to produce sharp image) **(1)**

max 3

- (c) (i) the fraction of X-rays removed per unit thickness of the material **(1)**
 (ii) the thickness of the material which will reduce the intensity
 to half its original level **(1)**
 for a specified energy of the X-rays (in either (i) or (ii)) **(1)**

2

(d) (use of $\mu = \frac{\ln 2}{t_{1/2}}$ gives) $\mu = \frac{\ln 2}{3.2} = 0.22 \text{ mm}^{-1}$ **(1)** (0.217 mm^{-1})

(use of $I = I_0 e^{-\mu x}$ gives) $I = 6.0 \times e^{-0.217 \times 2}$ **(1)**
(allow C.E. for value of μ)
 $= 3.9 \text{ W m}^{-2}$ **(1)**

3
[11]