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) $I / I_0 = 0.917$ ✓
$\ln (0.917) = -\mu \times 2.7 \times 10^{-3}$ ✓
$\mu = 32.1$ ✓
$\mu_m = \mu / 2700 = 0.012$ ✓
$m^2\ kg^{-1}$ ✓

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

5

[7]

M2. (a) (i) $1.60 \times 10^{-19} \times 72.5 \times 10^{3} = 1.16 \times 10^{-14}$ (J)

Sig Fig mark for 3sf

2

(ii) $\lambda = (6.63 \times 10^{-34} \times 3.00 \times 10^{8})/1.16 \times 10^{-14}$

$= 1.71 \times 10^{-11}$ (m)

2

(b) Narrow beam of X–rays

X ray generator rotated (in circular path) around patient

Detectors arranged around outside of the path

Detector opposite generator registers transmitted intensity

Detectors connected to computer which (over time) produces cross sectional image

Any **three** relevant points.

3

[7]

M3. (a) electrons strike anode and ionise/excite the target **atoms** ✓

excited/higher electrons fall to **inner** energy level ✓

fixed energy gaps produce fixed energy photons ✓

3

(b) convert X-ray (photons) to light (photons) ✓

light photons expose film in correct place due to closeness of the screens to the film ✓

reduces radiation dose to the patient/the exposure time is shorter ✓

3

[6]

M4. (a) specific to anode element/target atoms/material **(1)**
energy level transition **(1)**

2

(b) new curve to show:
entire curve has more intensity **(1)**
stops at 90 kV **(1)**
spikes in same position **(1)**

3

(c) % into heat = (100 – 0.70) = 99.3 **(1)**

rate of heat produced = $\frac{99.3}{100}$ × 80 × 10^{3} × 120 × 10^{-3} **(1)**

= 9.5 kW **(1)** (9.53 kW)

3

[8]

M5. technique: broken arm – X-ray, foetus – ultrasound **(1)**

reasons: (X-ray) good contrast
sharp image
good resolution any two **(1) (1)**

(ultrasound) non-ionising (safe)
detects change in tissue type
allows real-time image any two **(1) (1)**

[4]

M6. (a) (i) method 1: increasing pd across the tube **(1)**
method 2: increasing tube current or increasing filament temperature **(1)**

(ii) method 1: will increase the maximum photon energy **(1)**
method 2: will not change the maximum photon energy **(1)**

max 3

(b) reduces intensity of low energy photons **(1)**
hardly changes intensity of high energy photons **(1)**
need high energy for picture
[or low energy no good for picture] **(1)**
reducing low energy reduces dose received by patient **(1)**

max 3

[6]