1. (a) 6 points plotted correctly (1)
remaining point plotted correctly (1)
sensible continuous smooth graph drawn (1) 3

(b) (i) 0.95 +/– 0.10 mm (1) 1

(ii) $I / I_o = e^{-x}$ (1)
$0.50 = e^{-0.0009}$ (1)
$\mu = 730$ (1)
m^{-1} (1) 4

[8]

2. (a) Density (of medium) B1
Speed of ultrasound (in medium) or any factors that affect the speed of ultrasound in the medium e.g. Young modulus B1

(b) (i) blood:
$f = (1.59 \times 10^{-6} – 1.63 \times 10^{-6})^2 / (1.59 \times 10^{-6} + 1.63 \times 10^{-6})^2$
$f = 1.54 \times 10^{-4}$ B1
muscle:
$f = 1.70 \times 10^{-6} – 1.63 \times 10^{-6})^2 / (1.70 \times 10^{-6} + 1.63 \times 10^{-6})^2$ B1
$f = 4.4 \times 10^{-4}$ B1
so the medium is muscle A1
(bald muscle scores zero)

(ii) $(s = u \times t)$
$s = 1.54 \times 10^3 \times 26.5 \times 10^{-6} = 0.0408$ m C1
depth = 0.0408 / 2 = 0.020 m A1

(iii) $\lambda = 1.54 \times 10^3 / 3.5 \times 10^6$ C1
$= 4.4 \times 10^{-4}$ m A1
(do not penalise the same power of ten error in (iii) as in (ii)

[10]

3. (a) Low energy X-rays are absorbed by the skin / undesirable as can cause damage /greater ionising B1

(b) $I = I_0 e^{-\mu x}$ $\ln I = \ln I_0 – \mu x$ C1
$I_0 = 347 / e^{-250 \times 0.025}$ $\ln I_0 = \ln 347 + 250 \times 0.025$ C1
$I_0 = 1.79 \times 10^5$ Wm^{-2} A1

(c) $P = I \times A$

$P = 347 \times \pi \times (0.010 \times 10^{-2})^2$ C1

$P = 1.09 \times 10^{-3}$ W A1

[6]

4. (a) Low energy X-rays are absorbed by the skin / undesirable as can cause damage / greater ionising (1) 1

(b) $I = I_0 e^{-\mu x}$ (1) $\ln I = \ln I_o - \mu x$

$I_o = \frac{347}{e^{-250 \times 0.025}}$ (1) $\ln I_o = \ln 347 + 250 \times 0.025$

$I_o = 1.79 \times 10^5$ Wm^{-2} (1) 3

(c) $P = I \times A$ (0)

$P = 347 \times \pi \times (0.10 \times 10^{-2})^2$ (1)

$P = 1.09 \times 10^{-3}$ W (1) 2

(d) (i) $P = 18 \times 100 / 0.15$ (1)

$P = 12000$ W (1) 2

(ii) $12000 / 7.5 \times 10^{17}$ ($= 1.6 \times 10^{-14}$ J = energy of each electron) (1)

$0.5\ m\ v^2 = 1.6 \times 10^{-14}$ (0)

$v = 1.9 \times 10^8$ ms^{-1} (1) 2

(iii) tube current $= 7.5 \times 10^{17} \times 1.6 \times 10^{-19} = 0.12$ A (1)

$V \times I = 12000$ (1)

V =12000 / 0.12 = 100,000 V or 100 kV (1) 3

[13]

5. (a) (to a maximum of 7 marks) e.g.

- X-ray source + detectors round patient …
- … rotated around patient …/ the signal / X-ray passes through the same section of the body from different directions.
- … producing a (thin) slice / cross-section.
- Idea of absorption / less gets through / more is absorbed …
- by dense material / bone / material of high Z / High Z related to materials such as bone / Low Z to materials such as soft tissue
- attenuation is by the photo-electric effect
- the possibility of using a contrast medium.
- better than a simple X-ray at differentiating other organs.
- patient is moved a small distance and the process is repeated / process continues in a spiral.
- a computer (analyses the data) / identifies the position of organ/bone …
- … and forms a 3-D image. 7

(b)
- Patients are exposed to <u>ionising</u> radiation. (1)
- (Ionising radiation) could cause cancer / damage cells (1)

Plus a maximum of ONE from:-e.g. (1)

- It's expensive.
- Time consuming / uses valuable resources, etc.. 3

[10]

6. (i)
- 5.4 cm +/– 0.1 cm read from the graph (1)
- = $5.4 \times 20\ \mu s\ cm^{-1} \times 1.5 \times 10^3\ m\ s^{-1}$ (1)
- = 0.162 m (1)
- 0.162 / 2 = 0.081 m or 8.1 cm (1) 4

(ii)
- High reflection at the air-skin boundary / Little ultrasound enters the body / A very large peak right at the start … (1)
- … due to large <u>difference</u> in <u>acoustic impedance</u> / allow '…due to large <u>difference</u> in <u>density</u>'. (1)
- Very low <u>peaks</u> / no (subsequent) <u>peaks</u> (not just 'nothing') (1) 3

[7]

7. Any **six** from:
method does not use ionising radiation
hence no radiation hazard to patient or staff
gives better soft tissue contrast than CT scans
generates data from a 3D volume simultaneously
information can be displayed on a screen as a section in any direction
there are no moving mechanisms involved in MRI
There is no sensation, after effects at the field strengths used for routine diagnosis
Strong magnetic field could draw steel objects into the magnet
Metallic objects may become heated
Cardiac pacemakers may be affected by the magnetic fields
CT scanners better for viewing bony structures B1 × 6

[6]

8. alternating voltage or alternating E-field across crystal (1)
at resonant frequency (1) allow reference to resonance of crystal 2

[2]

9. **Formation of image to a max 3** e.g.

X-rays are detected by a film / scintillation counter etc., (1)
High 'Z' means high attenuation / low transmission
[Allow atomic mass / nucleon number] (1)
shadow on the film / reference to exposure after attenuation (1)
Reference to photoelectric effect / energy range around 1–100keV /
absorption $\propto Z^3$ (1)

Explanation of the use of a contrast medium to a max.4 e.g.

X-rays do not differentiate / show up soft tissues well …(1)
… as similar absorption / 'Z' is similar / 'Z' is low for these tissues. (1)
Contrast medium has high 'Z' / absorbs X-rays strongly.(1)
It is usually taken orally / as an enema / can be injected.(1)

Example of type of structure that can be imaged to a max.1 e.g.

digestive tract / throat / stomach.(1) to a max. 8

[8]