Mark schemes

Q1.

The mark scheme gives some guidance as to what statements are expected to be seen in a 1- or 2-mark (L1), 3- or 4-mark (L2) and 5- or 6-mark (L3) answer. Guidance provided in section 3.10 of the 'Mark Scheme Instructions' document should be used to assist in marking this question.

Mark	Criteria
6	All three areas covered with at least two aspects covered in some detail. There should be at least one statement from the conclusions. Can be awarded even if there is an error and/or parts of one aspect missing.
5	A fair attempt to analyse all three areas, with two areas discussed successfully and one are partially.
4	Two areas successfully discussed, or one discussed and two others covered partially. Whilst there will be several gaps, there should only be an occasional error.
3	One area discussed and one discussed partially, or all three covered partially. There are likely to be several errors and omissions in the discussion.
2	Only one area discussed, or makes a partial attempt at two areas.
1	None of the three areas covered without significant error.
0	No relevant analysis.

Ignore references to body parts other than ribs, heart, lung.

Statements can be in terms of transmission or absorption.

Area 1: Brightness
Film is darkened by X-rays.
More X-rays darker film / lighter areas have fewer X-rays.

Brightness:
Heart > ribs >> lungs
Lungs allows the most X-rays to be transmitted and are darkest.
Heart allows the fewest X-rays to be transmitted and is lightest.
Rib allows more X-rays than the heart but fewer than lungs to be transmitted and is medium brightness.

Area 2: Thickness
Thicker tissue decreases the amount of X-rays transmitted.
Reference to exponential decrease in X-rays transmitted with thickness.

Rib<< heart < lungs
Rib - very thin, so transmits more X-rays than heart.
Heart - much thicker than rib transmits less X-rays.
Lung - very thick (but transmit most X-rays).

Area 3: Half-value thickness
Half-value thickness is the thickness needed to reduce intensity by half.
Larger $x_{1/2}$ increases the amount of X-rays transmitted for the same thickness.

Half value thickness:
Lungs >> heart > ribs
Rib has smallest $x_{1/2}$ (most dense)
Heart has medium $x_{1/2}$ (medium density)
Lung has largest $x_{1/2}$ (least dense)

Conclusions
Ideas that:
Heart brightest as it has medium $x_{1/2}$ but is thick Rib almost as bright as heart as it has smallest $x_{1/2}$ but is much thinner.
Lung darkest as although thicker, it has highest $x_{1/2}$

6

(b) Idea of ingestion of barium meal/ contrast medium ✓

Do not allow any response suggesting ingestion of a radioisotope

To improve contrast of image / to increase the number of X-rays absorbed (by contents of stomach) / barium is a good absorber of X-rays/ barium has high attenuation (coefficient) ✓

Do not award MP2 without MP1 being given.

MP2: ignore 'has higher atomic number'

Do not allow reference to increased reflection.

2

[8]

Q2.

(a) Flat panel detector ✓

If flat panel detector, **max 3** from:

Not moving, so fluoroscopic image intensity not required ✓

Saves a picture unlike an intensifying screen ✓

FTP digital image is easier to share or transfer unlike film ✓

Flat panel detector is more sensitive (than film) ✓

Faster than film / film is slower / doesn't have to be developed like film ✓

To minimise dose of X-rays to be used ✓

If film selected

Not moving, so film is preferred to intensifying screen ✓

Saves a picture unlike an intensifying screen ✓

Minimise dose of X-rays to be used (compared to moving image with intensifying screen) ✓

Do NOT accept minimise dose compare to flat panel detector

If image intensifier selected

Intensifying screen is more sensitive (than film) ✓

Condone increases contrast (at low intensity) as an alternative to increase sensitivity

Does not need to be developed like film / real time image ✓

If no selection is made max 2 for correct comments.

Ignore references to resolution / image quality

Treat cost / portability as neutral

4

(b) First mark is for calculating intensity (or power or energy if calculation done in a different order) transmitted through bone (allow thickness < 4 cm if justified as mean eg $r\sqrt{\pi}$ accept r = 0.02 < thickness ≤ d = 0.04) must include a factor $e^{-\mu x}$ ✓

Second mark is for calculating intensity absorbed by bone (or power or energy if calculation done in a different order) ✓

Third mark is for calculating the area of the bone ✓
Fourth mark is for converting an intensity into a power (allow ecf for incorrect intensity, including I_0, or area) ✓
Fifth mark is for converting a power into an energy (allow ecf for incorrect energy) ✓

Expected answer

$I = I_0 e^{-\mu x} = 0.013 \times e^{-58.3 \times 0.04}$ ✓ *(= 0.00126)*

Absorbed intensity = $I_0 - I = 0.013 - 0.00126$ ✓ *(= 0.0117)*

Area of bone = $\sqrt{0.25^2 + 0.09^2} \times 0.04$ ✓ *(= 0.0106 m²)*

$P = IA = 0.0117 \times 0.0106$ ✓ *(= 0.000124)*

$E = Pt = 0.000124 \times 0.8 = 1.0 \times 10^{-4}$ ✓ *(J)*

(allow 9.9×10^{-5} or 1.1×10^{-4})

Condone rounding of answers/values as estimate asked for.

Award max 4 if PoT error in final answer.

5

(c) Assuming bone has constant thickness / bone is rectangular/cuboid ✓

Allow any other sensible assumption that leads to a larger value

For the first mark it must be clear that the distance referred to is x in the equation $I = I_0 e^{-\mu x}$ and not the mean diameter used to calculate the cross sectional areas.

First mark can also be gained from an attempt to use an average value for x in ***(b)***

Assuming none of the X-rays are absorbed by tissue before it reaches the bone ✓

Allow some X-rays are scattered (rather than being absorbed) ✓

Treat references to X-rays reflecting as neutral

2

[11]

Q3.

The mark scheme gives some guidance as to what statements are expected to be seen in a 1 or 2 mark (L1), 3 or 4 mark (L2) and 5 or 6 mark (L3) answer.
Guidance provided in section 3.10 of the 'Mark Scheme Instructions' document should be used to assist in marking this question.

Mark	Criteria
6	Ultrasound or CT identified and justified, quality comments on all 3, at least 3 other factors. Must refer to resolution / detail for 6 marks.
5	Ultrasound or CT identified and justified, quality comments on all 3, at least 2 other factor. Must differentiate between the quality of CT and ultrasound for kidney stones.
4	Ultrasound or CT scanner identified. Quality comments on all 3 or 2 quality comments and 1 other factor.
3	Ultrasound or CT scanner identified. 2 comments including at least 1 quality comment Or MR scanner identified and stated as highest resolution, with 2 quality comments and 2 others factors.
2	Any choice, with a relevant supporting argument (allow MR scanner as highest resolution provided one other relevant factor is provided). Or At least 3 valid comments with no choice made.
1	Any valid comments (ignore MR scanner as highest resolution).
0	No relevant comments.

Points to consider:

Relevant quality
- MR scanner – low quality image of calcium / kidney stones (allow cannot see)
- CT scanner – high resolution image of kidney stone
- Ultrasound – low resolution image of kidney stone

(Allow CT scanner and Ultrasound produce good images of kidney stone but not for 6 marks)
Allow references to bone instead of kidney stone

Other factors
- (CT scanner / MRI is more expensive than ultrasound)
- Ultrasound / MRI causes no harm
- CT scanner emits ionising radiation
- Ionising radiation damages cells
- Do not have to remain still for ultrasound
- Ultrasound is fastest / real time
- MRI can cause claustrophobia

Ignore references to metal / pace maker in the body for MRI
Ignore references to 3D images

Justified choice
- Ultrasound
- Quality is good enough, (cheaper) and safe

- CT
- Best quality image of kidney stones
- (except for pregnant women and children)

[6]