M1.(a) (i) Z values calculated correctly 1.617×10^6 and 1.341×10^6

Allow substitutions in equation

C1

Substitute their values in formula for I_r / I_i

C1

0.87%

A1

3

(ii) Uses $v=f\lambda$ in any form condone incorrect power of 10

C1

7.7×10^{-4} (m)

A1

2

(b) The marking scheme for this question includes an overall assessment for the quality of written communication (QWC). There are no discrete marks for the assessment of QWC but the candidate's QWC in this answer will be one of the criteria used to assign a level and award the marks for this question.

Descriptor − an answer will be expected to meet most of the criteria in the level descriptor.

Level 3 − good:
claims supported by an appropriate range of evidence
good use of information or ideas about physics, going beyond those given in the question
argument well structured with minimal repetition or irrelevant points
accurate and clear expression of ideas with only minor errors of grammar, punctuation and spelling.

Level 2 − modest:
claims partly supported by evidence
good use of information or ideas about physics given in the question but limited beyond this
the argument shows some attempt at structure
the ideas are expressed with reasonable clarity but with a few errors of grammar, punctuation and spelling.

Level 1 − limited:
valid points but not clearly linked to an argument structure
limited use of information about physics

unstructured
errors in spelling, punctuation and grammar or lack of fluency.
Level 0:
incorrect, inappropriate or no response.

5 / 6 Expect a coherent account incorporating at least 4 from each section
3 / 4 Account may cover the first part well and give a more superficial account of the second giving one or two points. Or two or three points from each section.The structure may not make it easy to follow
1 / 2 Provides superficial response for one of the topics and may be brief and poorly expressed

5−6 *Answer addresses both bullets. The first should be very clear and have no significant omissions. The second may be less well done but the effect of different acoustic impedances at the boundaries should be there should be covered clearly*

3−4 *Both aspects are likely to be addressed but there will be less coherence in the response and significant points may be omitted*

1−2 *There is likely to be a superficial qualitative response probably more inclined toward the first bullet point*

Examples of creditworthy statements*:*

1 Transducer swept across surface of skin

2 Emits pulsed ultrasound signal

3 Reflected at boundaries where acoustic impedance changes

4 Time for pulse to return is measured

5 Depth of boundary calculated / position of boundary is plotted

6 Equation relating to establishing depth

1 Acoustic impedance is resistance to passage of sound through the medium

2 Causes attenuation of ultrasound

3 Causes reflection of sound at a boundary

4 Is needed in order to produce image

5 Reduced by use of gel on skin

6

(c) Ability to distinguish between objects that are close together.
Smallest angle that objects can subtend the observer and be seen as separate
OWTTE

Not clarity or number of pixels

B1

Idea that the smallest structure visible on image is comparable with wavelength
Mention of diffraction

B1

2L

[13]

M2.(a) any **three** points from:

supplied radio pulse excite H **nuclei**

when H nuclei de-excite / change spin / change alignment they emit radio photon / signal / em radiation

these signals are detected and passed to computer

gradient in static magnetic field

to allow location to be determined
or magnetic field aligns nuclei

Allow Hydrogen protons for nuclei

Max 3

(b) **any two reasons**, eg

(non-ionising) so no known harm caused to unborn baby,

Accept correct reverse arguments for X-rays

gives good images of soft tissue
relatively cheap

Do not allow better resolution

2

[5]

M3.(a) Alternating potential difference applied across the crystal ✓
causes crystal to expand and contract ✓
creating pressure waves in the crystal / plastic membrane ✓
frequency of alternating pd equal to that of crystal / resonant frequency of crystal ✓
which is above 20 kHz ✓
short application of ac to produce short pulse ✓
use of backing material to damp and stop vibration of crystal ✓

Max 4

(b) (i) correct calculation of ratio $I_r / I_i = 0.99896$ ✓
subtract from 1 and multiply by 100 to give 0.10% ✓

Do not give mark for 99.8

ecf from calc for 2nd mark

2

(ii) gel is between the probe and the skin to exclude air ✓
gel should have acoustic impedance equal / close to that of the skin / soft tissue ✓
to ensure maximum transmission / greatly increase transmission into the body:
or to minimise reflection / greatly reduce reflection at body boundary ✓

Max 2

[8]

M4. (i) density of the material **(1)**
speed of sound in the material **(1)**

(ii) large difference in acoustic impedance **(1)**

(iii) (position) between probe and skin **(1)**

(reason for gel): without it, trapped air gives large difference in acoustic impedance **(1)**
gel has similar acoustic impedance to tissue **(1)**
air excluded and maximum transmission **(1)**

max 3 for (iii)

[6]

M5. (a) electrodes connected to **alternating/high frequency** emf/voltage/pd **(1)**
crystal expands and contracts at frequency of emf **(1)**
[or resonates at same frequency]
vibration of faces produces ultrasound/pressure waves **(1)**
backing material damps oscillations of crystal **(1)**
to stop crystal oscillating between end of transmitted pulse and start of reflective pulse **(1)**

Max 3
QWC 1

(b) (i) (probe acts as receiver and) received signal causes crystal to vibrate **(1)**
vibration of crystal produces alternating pd **(1)**

(ii) transmission must stop so that reflected pulse can be received **(1)**

3

[6]

M6. 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]