Mark schemes

1. (a) Calculation of area

A (= $4\pi r^2$) = $4\pi 12^2$(= 1810) ✓$_1$ (m^2)

Calculation of intensity

$I = \frac{P}{A} = \frac{17}{1810}$ (= 9.49×10^{-3}) ✓$_2$ ($W\ m^{-2}$)

ecf for ✓$_2$ if area calculation attempted

Calculation of intensity level

$I = 10 \log \frac{9.49 \times 10^{-3}}{10^{-12}} = 100$ ✓$_3$

ecf for ✓$_3$ even if no area calculation attempted

3

(b) The sound would be quieter ✓

ear is most sensitive at 3 kHz ✓

2

[5]

2. (a) Mention of ear's sensitivity starting low, increasing to maximum and then falling again resulting in convex nature of their curve which is wrong as does not fall after 5 kHz / should fall at higher frequencies and not plateau ✓

Mention of 1 kHz being the reference frequency for both scales / mention of 3 kHz being the frequency of maximum sensitivity of the ear ✓

both scales should have same reading at 1 kHz which they don't / it is wrong that the curves cross at about 750 Hz ✓

dBA curve should have maximum value at 3 kHz which it doesn't / wrong as max sensitivity of dBA scale is shown at 4 kHz ✓

4

(b) Initial use of 110 dB in correct equation –

110 = 10 log (I / I_0)

leading to correct calculation of intensity = 0.10 (W m^{-2}) ✓

Use of equation the calculated intensity = 7.8 / $4\pi r^2$ ✓

Leads to distance = 2.5 m ✓

Thus 2 m is slightly too close to the drill as it is less than 2.5ml ✓

The 4 marks are basically

1. The correct manipulation of the equation relating intensity and power.

2. The correct answer from this.

3. The correct use of the decibel equation.

4. A suitable statement relating numbers.

These marks can come in any order depending on how they attack the problem. They may do 3 before 1 and 2, as in my original mark scheme, but many are doing 1 and 2 before 3.

If 1 is wrong then this is EOP and thus 2 cannot be awarded, but 3 and 4 are ECF and are still available.

Be aware that by using the initial power and distance quoted in the question, the final answer for the intensity level is 112 dB. Some candidates may then say that to 2sf, this is 110 dB which is that quoted as the safe level. This argument must be given the credit which it deserves.

Remember that ECF is available from 2 to 3, or from 3 to 1 and 2.

The final mark is for a sensible comment based on their final answer with some numeric comparison.

4

[8]

3. (a) $I \propto \frac{1}{A} = \frac{1}{r^2}$ or

$P = IA$ = 3.4 × 10^{-8} × $4\pi 11^2$ ✓ (=5.17 × 10^{-5} W)

Either ($I = \frac{3.4 \times 10^{-8} \times 11^2}{7^2}$ or $I = \frac{P}{A} = \frac{5.17 \times 10^{-5}}{4\pi 7^2}$)

= 8.4 × 10^{-8} W m^{-2} ✓

M1 Working mark

Evidence of either a proportion calculation or calculation of power from intensity

Use of $I \propto \frac{1}{r^2}$ with the wrong factor for r still scores M1 (but not M2)

M1 cannot be awarded if πr^2 is used for the area but M2 can still be awarded.

1

(b) One from

$I_1 = I_0 10^{\frac{IL}{10}}$ = $10^{-12} \times 10^{4.2} = 1.58 \times 10^{-8}$ W m^{-2} or

$I_2 = I_0 10^{\frac{IL}{10}}$ = $10^{-12} \times 10^{6.5} = 3.16 \times 10^{-6}$ W m^{-2} or

$\frac{I_2}{I_1} = 10^{6.5-4.2}$ or $\frac{I_2}{I_1} = \frac{10^{6.5}}{10^{4.2}}$ ✓

$\frac{I_2}{I_1}\left(= \frac{3.16 \times 10^{-6}}{1.58 \times 10^{-8}} \text{ or } 10^{6.5-4.2}\right) = 200$ ✓

Correct values for I_1 or I_2 or a correct rearranged substitution can gain M1

Ignore any units given

Accept anything from a correct calculation that rounds to 200 to 2SF

1
1

(c) Intensity level must be stated

uses a **logarithmic** scale ✓

which matches the response of the human ear ✓

*Do not allow matches the **frequency** response of the human ear for the second mark.*

Mark 2 is dependent on mark 1

1
1

(d) **P and Q** would hear (all frequencies) at lower volume/quieter than **R**. ✓

P would experience most hearing loss at high frequencies (compared to **R**) ✓

Q would experience most hearing loss at/around 4 kHz (compared to **R**) ✓

If no other marks are given allow 1 mark for

P hears at a lower volume/quieter than R and Q's hearing loss is frequency dependent✓

1
1
1

[9]

4. (a) Ossicles act like levers ✓

To increase the force ✓

2

(b) Area of ear drum $= \frac{\pi d^2}{4} = \frac{\pi 0.01^2}{4}$ ✓1 $= 7.85 \times 10^{-5}$ (m^2) = 7.85×10^{-5} (m^2)

ignore PoT for ✓$_1$

Increase in pressure due to window size = $\frac{5.0 \times 10^{-2}}{2.5 \times 10^{-3} \times 1.5} = 13.3$

(or 1/13.3 = 0.075) ✓$_2$

if mix up r and d ecf for ✓$_2$ and ✓$_3$

dividing gain or area by 1.5 or multiplying force by

1.5 gains ✓$_2$ (allow a factor between 1.5 to 5)

Area of oval window = $\frac{7.85 \times 10^{-5}}{13.3} = 5.9 \times 10^{-6}$ (m^2) ✓$_3$ = 5.9×10^{-6} (m^2) ✓$_3$

correct PoT needed for ✓$_3$ (process mark for calculating area, answer may differ from that shown when a different factor for the effect of ossicles are used)

ignoring 1.5 from ossicles and calculating

A = 3.9×10^{-6} (m^2) scores ✓$_1$ and ✓$_3$

Alternative method for ✓$_2$ and ✓$_3$

Force on ear drum = PA = $2.5 \times 10^{-3} \times 7.85 \times 10^{-5} = 1.96 \times 10^{-7}$ N

Force on oval window

= $1.96 \times 10^{-7} \times 1.5$ ✓$_2$

Area of oval window = $\frac{F}{P} = \frac{2.94 \times 10^{-7}}{5.0 \times 10^{-2}} =$

5.9×10^{-6} ✓$_3$ (m^2)

3

[5]