3	**The only correct answer is C** A is not correct because frequency increases B is not correct because time period decreases D is not correct because wavelength decreases	**1**

2	The only correct answer is **D** A is not correct because amplitude can be read from the graph B is not correct because frequency is the reciprocal of time period C is not correct because time period can be read from the graph	**1**

2	**C is the correct answer** as a path difference of λ is equivalent to a phase difference of 360°, so $3\lambda/8$ is equivalent to 3/8ths of 360° which = 135° A is not the correct answer as 34° is 3/8ths of 90° B is not the correct answer as 68° is 3/8ths of 180° D is not the correct answer as 270° is 3/8ths of 720°	**(1)**

3	**D is the correct answer as the shorter the pulse, the shorter the time over which reflections are received.** A is not the correct answer as only some of the ultrasound is reflected B is not the correct answer as the air is less dense than body tissues C is not the correct answer as higher resolution is gained with smaller λ	**(1)**

6	**The only correct answer is D** A is not correct because the change in displacement is downwards B is not correct because the change in displacement is downwards C is not correct because the change in displacement is downwards	**1**

3	**The only correct answer is D** $\left(\frac{1}{4 \times 0.005}\right)$ A is not correct because this gives the time period of the wave B is not correct because this gives half the time period of the wave C is not correct because the denominator is half the time period	**1**

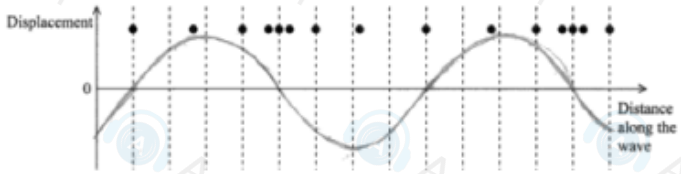
7	**C is the correct answer as the path difference of 12cm is half the wavelength, causing destructive interference (no heating).** A is not the correct answer as the path difference of 12cm would only cause maximum heating if it was a multiple of the wavelength B is not the correct answer as the path difference of 12cm would only cause maximum heating if it was a multiple of the wavelength. D is not the correct answer as the path difference of 12cm would only cause no heating if it was an odd half multiple of the wavelength.	**(1)**

2	**B is the correct answer as decreasing the time period increases the frequency (f = 1/T)** A is not the correct answer as amplitude is unaffected by time period C is not the correct answer as speed is affected by both time period and wavelength D is not the correct answer as wavelength is affected by both time period and speed	**(1)**

Question Number	Answer		Mark
19ai	Minimum labelled at either rarefaction	(1)	**(1)**
19aii	Zero displacement at all compressions and/or all rarefactions. Two complete wave cycles shown.  (Allow graph inverted in relation to the one shown above)	(1) (1)	**(2)**
19bi	Describes an initial situation where the two traces are in antiphase / phase Record the position of the microphone (from the metre rule) **Or** Measure the distance from the loudspeaker to the microphone Move microphone (gradually) until the two traces are next in antiphase / phase Record the new position of the microphone and calculate the distance moved by the microphone **Or** Measure the new distance from the loudspeaker to the microphone and calculate the distance moved by the microphone Multiply calculated/measured wavelength by frequency to determine the speed **Or** Describes a suitable graph to determine the speed (MP5 - examples of suitable graphs are λ against $1/f$ or f against $1/\lambda$. Both would give a gradient of v which needs to be stated to achieve the mark)	(1) (1) (1) (1) (1)	**(5)**
19bii	Time period read off oscilloscope (from one point to the next in phase point) **Or** number of waves per second read off oscilloscope Time period (for both traces) is the same	(1) (1)	**(2)**
19biii	Use of $v = f\lambda$ Calculates λ of 8.5 cm (for 4.0 kHz) **and** 2.3 cm (for 15.0 kHz) Percentage uncertainty greater for 2.3cm than 8.5cm (so student correct) **Or** Percentage uncertainty greater for 15.0kHz than 4.0kHz (so student correct) **Or** Percentage uncertainty is reduced if measurements taken across several wavelengths (so student not necessarily correct) (Do not allow "uncertainty" for "percentage uncertainty") **<u>Example of calculation</u>** $\lambda = v/f = (340\ ms^{-1}) / (4000\ Hz) = 0.085\ m$ $\lambda = v/f = (340\ ms^{-1}) / (15000\ Hz) = 0.023\ m$	(1) (1) (1)	**(3)**
	Total for question 19		**13**

Question Number	Answer	Mark
18a	Use of speed = distance / time (1) Calculates distance travelled by sound in 3s = 1020 (m) **Or** calculates time taken for sound to travel 1 km = 2.94 (s) **Or** calculates speed to travel 1000m in 3 seconds = 333 (ms^{-1}) (1) Time taken by light to reach 1 km is almost instantaneous / 3.3×10^{-6} s so teacher is (approximately) correct. (1) <u>Example of calculation</u> For light, $t = d/v = 1000$ m / 3.00×10^{8} ms^{-1} = 3.33×10^{-6} s For sound, $t = d/v = 1000$ m / 340 ms^{-1} = 2.94 s Difference in arrival time = 2.94 s ≈ 3 s	**(3)**
18bi	Use of $Q = It$ (1) $Q = 0.75$ C (1) <u>Example of calculation</u> $Q = It = 25{,}000$ A × (30×10^{-6} s) = 0.75C	**(2)**
18bii	Use of $P = VI$ (1) $P = 3.0 \times 10^{13}$ W (1) <u>Example of calculation</u> $P = VI = (1.2 \times 10^{9}$ V) × 25,000 A = 3.0×10^{13} W	**(2)**
18biii	Use of $A = \pi r^2$ (1) Use of $R = \rho l/A$ (1) $\rho = 0.24$ (Ω m) (1) <u>Example of calculation</u> Cross sectional area of wire = $\pi r^2 = \pi\ (2.5 \times 10^{-2})^2 = 1.96 \times 10^{-3}$ m^2 $R = V/I = (1.2 \times 10^{9}$ V) / 25,000 A = 48,000 Ω ρ = RA/l = (48,000 Ω) (1.96×10^{-3} m^2) / 400 m = 0.235 Ωm	**(3)**
18biv	Air in the lightning channel has been ionised **Or** Lightning channel unlikely to have a uniform diameter / CSA (1)	**(1)**

18ci	Energy levels (in atoms) are discrete/specific (1) (Energy makes) electrons move up energy levels **Or** Electrons are excited (1) (Electrons) move back down energy levels, releasing photons **Or** (Electrons) are de-excited, releasing photons (1) Energy difference (between levels) is proportional to frequency of photon (resulting in line spectrum being produced) **Or** Photon energy is proportional to frequency (resulting in line spectrum being produced) (1)	**(4)**
18cii	Different atoms/elements have different (differences in) energy levels (1)	**(1)**
	Total for question 18	**16**

Question Number	Answer	Mark
14(a)(i)	One correct position for compression labelled (1  	**1**
14(a)(ii)	Correct wavelength 54 mm / 5.4 cm / 0.054 m (1	**1**
14(b)	Sine wave drawn with one wavelength between compressions (1) Zero displacement at both compressions **and** the rarefaction inbetween (1)  	**2**
	Total for question 14	**4**

Question Number	Answer		Mark
12	Position A: Constructive (superposition)	(1)	
	Position B: Destructive (superposition)	(1)	
	Constructive is when: waves are in phase **Or** path difference is λ	(1)	
	Destructive is when: waves are in antiphase **Or** path difference is 3λ / 2	(1)	**4**
	(MP3 and MP4 are not dependent upon MP1 and MP2) (MP3 – accept phase difference of 2π radians or 360°) (MP4 – accept phase difference of π radians or 180°). (Phase difference must refer to an angle, path difference to a distance) (MP3 – allow path difference of nλ) (MP4 – allow path difference of λ/2 or (n + ½)λ) (MP4 – do not allow out of phase) (Ignore references to nodes and antinodes)		
	Total for Question 12		**4**

Question Number	Answer		Mark
15(a)	Longitudinal waves Or (Creating a series of) compressions and rarefactions	(1)	
	Oscillations / vibrations of (air) molecules/particles/atoms	(1)	
	Oscillations / vibrations parallel to the direction of the (wave) travel	(1)	**3**
15(b)(i)	Spreading of a wave	(1)	
	When going around head / listener / obstacle **Or** When passing head / listener / obstacle (MP2 dependent on MP1)	(1)	**2**
***15(b)(ii)**	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate)		
	The intensity reaching the left ear is the same (for all frequencies)	(1)	
	Right ear intensity is (always) less than the left ear intensity	(1)	
	When sound has travelled further the energy/intensity is reduced **Or** When sound has travelled further it covers a greater area **Or** As sound has been reflected/absorbed by head	(1)	
	Intensity reaching the right ear decreases as frequency increases	(1)	
	Because higher frequencies are diffracted less **Or** because shorter wavelengths are diffracted less	(1)	**5**
	Total for question 15		**10**