5	**A is the correct answer** as a large change in density causes most of the ultrasound to reflect, so the ultrasound does not penetrate deeper into the body. B is not the correct answer as this does not affect whether ultrasound can enter the lungs C is not the correct answer as this does not affect whether ultrasound can enter the lungs D is not the correct answer as ultrasound is not considered to cause damage to the body.	**(1)**

9	A – not a correct description B – not a correct description **C - correct answer** D - not a correct description	**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**

9	**C is the correct answer** A is not correct because this would describe the motion if it was a stationary wave. B is not correct because in a complete time period F and G would then reverse direction again. D is not correct because the wave is travelling to the right, not to the left.	**1**

7	**D is the correct answer as coherence can only occur if the waves have the same frequency** A is not the correct answer as coherence does not require waves to be in antiphase, they just need a constant phase difference B is not the correct answer as coherence does not require waves to be in phase, they just need a constant phase difference C is not the correct answer as waves can still be coherent, even if their amplitudes are different.	**(1)**

9	**B is the correct answer as $7\lambda/4$ represents 3.5 radians, which is 1.5π radians out of phase.** A is not the correct answer as $3\lambda/2$ represents 3π radians which is antiphase C is not the correct answer as 3λ represents 6π radians which is in phase D is not the correct answer as $7\lambda/2$ represents 7π radians, which is antiphase	**(1)**

1	**B is the correct answer** (A path difference of λ would cause constructive interference A is not the correct answer as this path difference would cause destructive interference C is not the correct answer as this phase difference would cause neither constructive nor destructive interference D is not the correct answer as this phase difference would cause destructive interference	**(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

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)

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)

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)

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

10	**D is the correct answer as Z is a full cycle from V, and compressions are separated by one full wave cycle.** A is not the correct answer as W is neither a compression nor a rarefaction B is not the correct answer as X is a rarefaction C is not the correct answer as Y is neither a compression nor a rarefaction	(1)

7	**D is the correct answer** 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.	

5	**B is the correct answer** A is not the correct answer as the time period can be determined from the graph C is not the correct answer as the wave could be transverse or longitudinal D is not the correct answer as the wave could be transverse or longitudinal	**(1)**

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) Example of calculation 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) Example of calculation $Q = It$ = 25,000 A × (30×10^{-6} s) = 0.75C	**(2)**
18bii	Use of $P = VI$ (1) $P = 3.0 \times 10^{13}$ W (1) Example of calculation $P = VI$ = (1.2×10^{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) ρ = 0.24 (Ω m) (1) Example of calculation Cross sectional area of wire = $\pi r^2 = \pi (2.5 \times 10^{-2})^2 = 1.96 \times 10^{-3}$ m^2 $R = V/I$ = (1.2×10^{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
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
*17(a)	This question assesses a student's ability to show a coherent and logically structured answer with linkages and fully-sustained reasoning. Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning. The following table shows how the marks should be awarded for structure and lines of reasoning.	

	Number of marks awarded for structure of answer and sustained line of reasoning
Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughc	2
Answer is partially structured with some linkages and lines c reasoning	1
Answer has no linkages between points and is unstructured	0

Total marks awarded is the sum of marks for indicative content and the marks for structure and lines of reasoning

IC points	IC mark	Max linkage mark	Max final mark
6	4	2	6
5	3	2	5
4	3	1	4
3	2	1	3
2	2	0	2
1	1	0	1
0	0	0	0

Indicative content

IC1 Photons (of ultraviolet light)

IC2 cause (photo)electrons to be emitted

IC3 from (the surface of) the magnesium / ribbon

IC4 as the (photon) energy is greater than the work function of magnesium
Or as the frequency of the ultraviolet light is greater than the threshold frequency of magnesium

IC5 The electrons are attracted to the positively charged gauze (and create the current).

IC6 When the polarity is reversed the current is zero because the electrons no longer have enough kinetic energy to move across the gap
Or When the polarity is reversed the current is zero because the work function of copper is larger than the photon energy
Or When the polarity is reversed the current is zero because the threshold frequency of copper is larger than the frequency of ultraviolet light

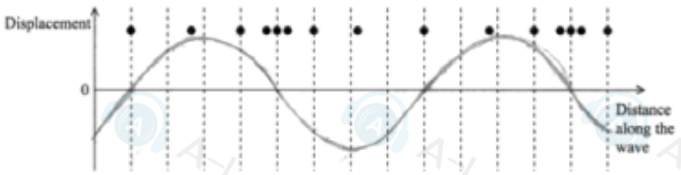
6

Question Number	Answer		Mark
15a	There is a decrease in speed/velocity	(1)	
	Part of the wavefront meets the boundary before the rest	(1)	
	(Ignore references to density and refractive index) (Allow MP2 for correct addition to the diagram by eye for wavefronts both before and after the boundary)		**(2)**
15bi	Use of $v = \sqrt{\frac{g\lambda}{2\pi}}$ to find speed in deep water	(1)	
	Use of $v = \sqrt{(gd)}$ to find speed in shallow water	(1)	
	Calculates ratio of speeds	(1)	
	Correctly equates ratio of speeds to ratio of sine of each angle	(1)	
	$r = 17°$	(1)	
	Example of calculation $v = \sqrt{\frac{g\lambda}{2\pi}} = \sqrt{\frac{(9.81 \text{ ms}^{-2} \times 15 \text{ m})}{2\pi}} = 4.8 \text{ ms}^{-1}$ (deep water) $v = \sqrt{(gd)} = \sqrt{(9.81 \text{ ms}^{-2} \times 0.50 \text{ m})} = 2.2 \text{ ms}^{-1}$ (shallow water) ratio of speeds = $(4.8 \text{ ms}^{-1}) / (2.2 \text{ ms}^{-1}) = 2.2$ $\sin r = \sin(40) / 2.2 = 0.29$ $r = 17°$		**(5)**
15bii	Use of $f = 1/T$ and $v = f\lambda$ to find speed of wave	(1)	
	Use of $v = \sqrt{\frac{g\lambda}{2\pi}}$ to find same speed in deep water, confirming that deep water equation is the correct equation for this wave	(1)	
	Deep water equation only works if $d > 342 / 2$ so d must be > 171m	(1)	
	Example of calculation $f = 1 / 14.8 \text{ s} = 0.0676 \text{ Hz}$ $v = 0.0676 \text{ Hz} \times 342 \text{ m} = 23.1 \text{ ms}^{-1}$ $v = \sqrt{\frac{g\lambda}{2\pi}} = \sqrt{\frac{(9.81 \text{ ms}^{-2} \times 342 \text{ m})}{2\pi}} = 23.1 \text{ ms}^{-1}$ (deep water)		**(3)**
	Total for question 15		**10**

14(a)	Oscillations / vibrations are perpendicular to the direction of energy transfer **Or** Oscillations / vibrations are perpendicular to the direction of wave travel (allow propagation for wave travel)	**(1)**	**1**

14(b)(i)	Uses appropriate trigonometry to determine θ	**(1)**	
	Use of $n\lambda = d\sin\theta$ to calculate d	**(1)**	
	Calculate $\frac{1}{d}$	**(1)**	
	Number of lines per mm = 260	**(1)**	**4**
	Example calculation $\theta = \tan^{-1}\left(\frac{0.22\text{ m}}{1.30\text{ m}}\right) = 9.61°$ $1 \times 650 \times 10^{-9}\text{ m} = d\sin(9.61°)$ $d = \frac{650 \times 10^{-9}\text{ m}}{\sin(9.61)} = 3.89 \times 10^{-6}\text{ m}$ No. of lines per mm = $\frac{10^{-3}}{3.89 \times 10^{-6}\text{ m}} = 257$		

14(b)(ii)	The path difference (for light from different slits travelling to the screen) is one wavelength	**(1)**	
	(So) the waves are in phase at the screen	**(1)**	
	(So) constructive interference occurs (causing a maximum)	**(1)**	**3**
	Total for question 14		**8**

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**