2	**The only correct answer is B** A is not correct because it has an incorrect use of the factor of 2 C is not correct because it is an incorrect arrangement D is not correct because there is no factor of 2	**1**

8	**D is the correct answer as decreasing the distance between the central maximum and the first order maximum would require sinθ to be reduced (presuming that the distance from the diffraction grating to the screen is unchanged), and $\lambda = \frac{d\sin\theta}{n}$** A is not the correct answer as this does not affect sinθ B is not the correct answer as this would increase the distance between the central maximum and first order maximum C is not the correct answer as more lines per mm would make d smaller, so as $d = \frac{n\lambda}{\sin\theta}$, which would make sinθ increas	**(1)**

	A - y and x are not the angle of incidence and angle of refraction respectively B - y and x are not the angle of incidence and angle of refraction respectively C - incorrect equation	
7	**D - correct answer**	**1**

7	**C π radians is the phase difference between the two waves at A – the path difference between the two waves is (8cm – 5cm) = 3cm = 1.5λ. This results in the waves arriving in antiphase (π radians out of phase) which also occurs when the path difference is 1cm.**	**1**
	Incorrect answers: A For a phase difference of π/4 radians, the path difference would be 0.25cm B For a phase difference of π/2 radians, the path difference would be 0.5cm D For a phase difference of 3π/2 radians, the path difference would be 1.5cm.	

2	**C is the correct answer as the distance between the laser and diffraction grating is not required in the equation $n\lambda = d\sin\theta$** A is not the correct answer as the distance from the diffraction grating to the screen is used to calculate θ in the equation $n\lambda = d\sin\theta$ B is not the correct answer as the distance from the central maximum to the first order maximum is used to calculate θ in the equation $n\lambda = d\sin\theta$ D is not the correct answer as the distance between the slits in the diffraction grating is used to calculate d in the equation $n\lambda = d\sin\theta$	**(1)**

9	**The only correct answer is B** A is not correct because amplitude will decrease C is not correct because velocity will decrease D is not correct because wavelength will decrease	**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)**

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)**

3	**The only correct answer is C - 0.5*vt*** **A** is not correct because the pulse has to travel to the object and back, so the distance should be halved. **B** is not correct because distance should be velocity × time and the pulse has to travel to the object and back, so the distance should be halved. **D** is not correct because distance should be velocity × time.	**1**

4	**The only correct answer is A (decreasing the length *l*)** B is not correct because lower tension would decrease the frequency C is not correct as strings with greater diameter vibrate with lower frequency D is not correct as strings with greater mass per unit length vibrate with lower frequency	**1**

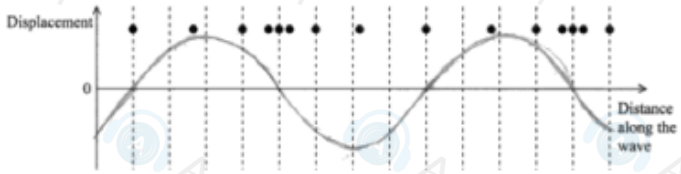
14(a)	Light must reach a boundary travelling in a medium of higher refractive index towards one of lower refractive index **Or** light must reach a boundary at which velocity would increase in the second medium **Or** light travelling in more dense medium towards a less dense [rarer] medium	(1)	
	Angle of incidence must be greater than (or equal to) the critical angle	(1)	**2**
14(b)	Use of $_1\mu_2 = \sin i / \sin r$	(1)	
	Either Critical angle = 60(°)	(1)	
	The ray will not totally internally reflect as the angle of incidence is smaller than the critical angle	(1)	
	Or Refracted angle = 35(°)	(1)	
	The ray does not totally internally reflect as the ray has refracted into the liquid	(1)	**3**
	Example of calculation $\frac{1}{1.15} = \frac{\sin i}{\sin 90} = 60.4^{o}$ So not TIR as this is more than 30°		

14(c)	Clear link between a mass change and a change in refractive index e.g. A 1 gram change corresponds to (~)0.001 change in refractive index **Or** a calculation of gradient	(1)	
	Comment that (to two sig figs) the refractive index values do not change		

Question Number	Answer		Mark
12(a)	Waves have been <u>reflect</u>ed by the <u>water</u> surface	(1)	
	Transmitted wave and reflected wave interfere **Or** waves travelling in opposite directions interfere	(1)	**2**
	(For MP2, allow 'superpose' for 'interfere') (For MP2, do not allow 'opposite waves')		
12(b)(i)	Use of $v = f\lambda$	(1)	
	With $\lambda = 4 \times$ length of column (or see 0.772m)	(1)	
	$v = 340\ ms^{-1}$	(1)	**3**
	<u>Example of calculation</u> $\lambda = 4 \times$ length of column $= 4 \times 0.193\ m = 0.772\ m$ $v = f\lambda = 440\ Hz \times 0.772\ m = 339.7\ ms^{-1}$		
12(b)(ii)	(Wave)length would be longer **Or** node to antinode distance would be longer	(1)	
	This would cause the value (for the speed of sound) to be higher (than calculated value, which is therefore less accurate)	(1)	**2**
	(MP2 dependent on MP1) (Answer can be written in the converse e.g. the wavelength used in the calculation is shorter, so the calculated speed is lower).		
	Total for Question 12		**7**

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**