Name: _____

interference

Date:

Time:

Total marks available:

Total marks achieved: _____

Mark Scheme

Q1.

Question Number	Answer	Mark
	B	1

Q2.

Question Number	Answer	Mark
	D	1

Q3.

Question Number	Answer	Mark
	A	1

Q4.

Question Number	Answer	Mark
	A	1

Q5.

Question Number	Answer	Mark
	B	1

Q6.

Question Number	Answer	Mark
	D	1

Q7.

Question Number	Answer	Mark
	C	1

Q8.

Question Number	Acceptable answers	Additional guidance	Mark
	D 90 degrees		1

Q9.

Question Number	Answer	Mark
	C	1

Q10.

Question Number	Answer	Mark
	C	1

Q11.

Question Number	Answer	Mark
	A $\frac{2\pi t}{T}$	1
	Incorrect Answers: B – no factor of 2 C – incorrect substitution of f D – incorrect substitution of f and no factor of 2	

Q12.

Question Number	Answer	Mark
	D originate from one source	**1**
	Incorrect Answers: A – coherence requires a constant phase difference not necessarily 0 B – planes not relevant C – amplitude not relevant	

Q13.

Question Number	Answer	Mark
	C	**1**

Q14.

Question Number	Answer	Mark
*(a)	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate) The waves superpose **Or** diffraction at the double slits **(1)** Where they are in phase **Or** when path difference is a whole number of wavelengths constructive interference takes place **(1)** Where they are in antiphase / when path difference is an odd number of half wavelengths destructive interference takes place **(1)** Bright bands are when waves are in phase / when path difference is $n\lambda$ / constructive interference **Or** reverse for dark bands **(1)**	**4**
(b)	coherent = constant phase relationship/difference (between light arriving from the two sources) **Or** if they are not coherent the phase relationship/difference will vary. **(1)** The idea that at a given point there would sometimes be constructive interference and sometimes destructive interference etc **(1)**	**2**
(c)	Interference (accept diffraction) only occurs with waves. **(1)**	**1**
	Total for question	**7**

Q15.

Question Number	Acceptable answers	Additional guidance	Mark
(a)	An explanation that makes reference to the following: • The light is diffracted (1) • (because) each point on wavefront acts as a source of secondary waves **Or** wavelets emitted (from points on the wavefront) (1)	Marks may be shown on a clearly labelled diagram	2

Question Number	Acceptable answers	Additional guidance	Mark
(b)	An explanation that makes reference to the following: • Path lengths (to centre of shadow from edge of ball) are equal (1) **Or** path difference (at spot) is zero • Will arrive in phase **Or** phase difference is zero (1) • (Bright spot is position of) constructive interference/superposition (1)		3

Q16.

Question Number	Answer	Mark
(a)	Idea of two or more waves meeting (1) Displacement is sum of individual displacements (1)	2

Question Number	Answer		Mark
(b) (i)	(QWC – Work must be clear and organised in a logical manner using technical wording where appropriate – e.g. if the term 'superimpose' is used this mark is not awarded)		
	When in phase constructive interference/superposition occurs **Or** when path difference is $n\lambda$ constructive interference/superposition occurs	**(1)**	
	When in antiphase destructive interference/superposition occurs **Or** when path difference is $(n + ½) \lambda$ destructive interference/superposition occurs	**(1)**	
	Light band forms when in phase **Or** path difference is $n\lambda$ **Or** constructive **Or** Dark band forms when in antiphase **Or** path difference is $(n + ½) \lambda$ **Or** destructive	**(1)**	**3**
(b) (ii)	Oscillations of light from the two filters are perpendicular to each other	**(1)**	
	So there are no opposite components to cancel each other out **Or** so the waves do not interact/interfere	**(1)**	
	So zero amplitude not possible	**(1)**	
	OR (If the candidate assumes that it is a source of polarised light) One filter is parallel to the plane of polarisation of the light source, so light is transmitted but the other one absorbs light	**(1)**	
	So light now only reaches the screen from one filter, so there is no interference	**(1)**	
	So zero amplitude not possible	**(1)**	**3**

Q17.

Question Number	Acceptable answers		Additional guidance	Mark
(i)	• use of strain = extension / length	**(1)**	Example of calculation Change in length = $1.2 \times 10^{-21} \times 4000$ m = 4.8×10^{-18} m Fraction of proton diameter = 4.8×10^{-18} m ÷ 8.8×10^{-16} m = 0.0055	
	• change in length = 4.8×10^{-18} (m) **Or** max strain for 0.001× proton size = 2.2×10^{-22}	**(1)**		
	• comparison of their change in length to 8.8×10^{-19}(m) **Or** comparison of their max strain to 1.2×10^{-21}	**(1)**		**3**

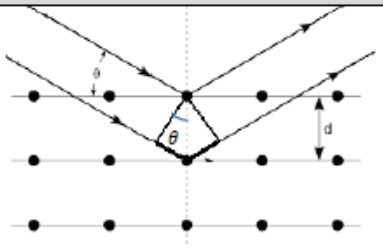
Question Number	Acceptable answers		Additional guidance	Mark
(ii)	• half wavelength path difference means waves in antiphase	**(1)**	Do not accept 'out of phase' for MP1	
	• so destructive interference takes place	**(1)**		
	• this results in zero amplitude, (so no signal detected)	**(1)**		
	• a change in length will result in a change in path difference, so signal detected **Or** a change in length will result in a change in phase difference, so signal detected	**(1)**	Accept reference to being 'not out of phase' for MP4	**4**

Question Number	Acceptable answers		Additional guidance	Mark
(iii)	• if initially the path difference is zero there will be a maximum signal • a change from max amplitude would represent a much smaller percentage (therefore less sensitive)	(1) (1)	MP2 alternative: a change from minimum amplitude would represent a much larger percentage (therefore more sensitive) MP2 Accept 'it is easier to detect the change from no light to light' MP2 Accept suitable reference to uncertainty	2

Q18.

Question Number	Acceptable Answers		Additional guidance	Mark
	• Waves (from gaps) superpose/interference • Constructive (interference) when waves are in phase **Or** path difference is $n\lambda$ • Destructive (interference) when waves are in antiphase **Or** path difference is $(n+\frac{1}{2})\lambda$ • Links constructive interference to maximum intensity **Or** links desructive interference with minimum/zero intensity	(1) (1) (1) (1)	Not superimpose MP3 Do not accept out of phase	4

Q19.

Question Number	Acceptable answers		Additional guidance	Mark
(i)	• Identification of θ between a wavefront and a vertical line • Clear evidence of extra distance before **and** after reflection	(1) (1)		2

Question Number	Acceptable answers		Additional guidance	Mark
(ii)	• There is more than one order (of diffraction)	(1)	Accept: path difference of one λ for 1st ring and 2 λ for 2nd ring rings occur for any whole number of wavelengths each ring corresponds to a different layer of atoms from which the electrons reflect.	1

Q20.

Question Number	Answer		Mark
(a)	Calculates path difference = 12 (cm) Phase difference 0, 360° or 2π **Or** Calculates number of wavelengths in two paths Phase difference 0, 360° or 2π	(1) (1) (1) (1)	2
(b)	Waves superpose **Or** interference between two waves takes place In phase constructive **Or** Antiphase destructive Links to <u>amplitude</u> maximum **Or** <u>amplitude</u> zero respectively In phase/constructive/max amplitude is where chocolate is hot with opposite at cold spots. **Or** Antiphase/destructive/min amplitude is where chocolate is cold with opposite at hot spots.	(1) (1) (1) (1)	4
(c)	Coherent means a constant phase relationship (If the relationship not constant) a point could sometimes be constructive and sometimes destructive	(1) (1)	2
(d)	Use of $c = f\lambda$ Calculates $c = 2.94 \times 10^8$ (m s^{-1}) **Or** $\lambda = 12.2$ (cm) **Or** $f = 2500$ (MHz) Sensible comment based on their calculated value. e.g. close to real value, so successful **Or** reference to uncertainty in data <u>Example of calculation</u> $c = 2.45 \times 10^9$ Hz × 0.12 m $c = 2.94 \times 10^8$ m s^{-1}	(1) (1) (1)	3
	Total for question		11

Q21.

Question Number	Acceptable Answers	Additional guidance	Mark
(i)	• Amplitude/energy/intensity of the soundwave reduces with distance travelled **(1)** • Appreciate that at A **or** B two waves are interfering destructively **Or** at A **and** B there are nodes **(1)** • at B the waves have travelled similar distances so have similar amplitudes **(1)**	Assume they are talking about point B unless stated otherwise For MP3 Accept answers with respect to waves at point A having different amplitudes due to different distances	**3**

Question Number	Acceptable Answers	Additional guidance	Mark
(ii)	• Uses graph to identify $\lambda = 0.16$ (m) **(1)** • Use of $v = f\lambda$ with a valid value from the graph **(1)** • $v = 320\ \text{m s}^{-1}$ **(1)**	using $\lambda = 0.08$ gives $v = 160\ \text{m s}^{-1}$ MP2 only Example of Calculation $v = 2000\ \text{Hz} \times 0.16\ \text{m} = 320\ \text{m s}^{-1}$	**3**

Q22.

Question Number	Answer		Mark
(a)	(sound waves travel as) longitudinal waves **Or** (Air molecules) vibrate parallel to direction of travel of wave	(1)	
	(sound waves travel as) a series of compressions **and** rarefactions **Or** (sound waves travel as) areas of high and low pressure	(1)	
	The idea that these vibrations create a pressure/force/stress/strain on the film **Or** The idea that these compressions/rarefactions create a pressure/force/stress/strain on the film	(1)	
	This pressure/force/stress/strain generates a potential difference (accept idea that vibration/pressure/force/stress/strain causes redistribution of charge within crystal)	(1)	**4**
(b)	Thin film is flexible / lightweight	(1)	
	The idea that there is not much energy in sound	(1)	
	Large area gathers more sound (energy) **Or** Large area generates more power/current/pd	(1)	**3**
(c)	Use of $P=E/t$ with any time, energy in J or kJ Conversion of kJ→J **and** correct time in s (36000 s) P =0.56 W (accept J s^{-1}) Example of calculation Power = 20000 J / 10 × 3600 s Power = 0.56 W	(1) (1) (1)	**3**
(d)	**ONE** *Disadvantage* Expensive, Not washable Only works with (loud) noise Long time to charge a phone Low output power	(1)	
	ONE *Advantage* Free source of energy Lower/zero running cost Portable Can be used when away from mains electricity	(1)	**2**
	[Credit should be given for any reasonable correct physics point but not for generalised comments such as 'good for the planet' 'environmentally friendly']		

Q23.

Question Number	Answer		Mark
*(a)	**(QWC – Work must be clear and organised in a logical manner using technicalwording where appropriate)** a standing/stationary wave Waves from the generator are reflected at the end **Or** waves are travelling in both directions (When the two) waves (meet they) superpose/undergo superposition Producing points where the waves are in phase and points where they are in antiphase **Or** producing points of zero amplitude and points of maximum amplitude OR producing nodes and antinodes	(1) (1) (1) (1)	4
(b)	Wavelength = 2 × 1.8 m Use of speed = wavelength x frequency Speed = 1200 m s^{-1} Example of calculation λ = 2 × 1.8 m v = 330 Hz × 3.6 m v = 1188 m s^{-1}	(1) (1) (1)	3
(c)(i)	Point is a node, so zero amplitude OR Point is a node, so string not moving So no energy absorbed **Or** Waves continue to move after superposition	(1) (1)	2
(c)(ii)	(Original frequency x 2) = 660 Hz	(1)	1
(c)(iii)	Captured twice per cycle = 1320 Hz (allow ecf from (c) (iii)) If more than 1320 Hz will be captured at points other than max amplitude	(1) (1)	2
(d)	Scale divisions of 20 Hz **Or** Wide pointer **Or** nominal output (only) Lack of precision (scale related) **Or** Lack of accuracy (output related)	(1) (1)	2
	Total for question		**14**

Q24.

Question Number	Answer		Mark
(a)	Force (or acceleration): • proportional to displacement from equilibrium/undisplaced/rest position	(1)	
	• always acting towards the equilibrium/undisplaced/rest position **Or** always in the opposite direction to the displacement	(1)	2
(b)(i)	Acceleration is a maximum at an extreme position (towards X) Acceleration decreases to zero at X	(1) (1)	2
(b)(ii)	**Max 3** Total energy remains constant	(1)	
	(Elastic) potential energy is transferred to kinetic energy as string moves towards X	(1)	
	Kinetic energy is zero at an extreme position and a maximum at X	(1)	
	(Elastic) potential energy is a maximum at an extreme position and a minimum at X	(1)	3
(c)	Use of $\lambda = 2l$ Use of $v = f\lambda$ $f = 250$ Hz	(1) (1) (1)	3
	Example of calculation: $\lambda = 2 \times 0.53\ m = 1.06\ m$ $f = v/\lambda = 270\ m\ s^{-1}/1.06\ m = 254.7\ Hz$		
	Total for question		10