Marking Scheme

#1

Question		Marking details	Marks available					
			AO1	AO2	AO3	Total	Maths	Prac
	(a)	d and θ labelled (1) $d\sin\theta$ is the path difference stated **and** shown (1) Equals $n\lambda$ for in phase / constructive / bright (1)	3			3	1	
	(b)	$d = \frac{1}{\text{number}}$ used or implied (1) Values substituted into $n\lambda = d\sin\theta$ **ecf** on d (1) At least one correct angle 7.6° or 15.4° (no **ecf** here) (1) Correct answer (accept 7.8° or 7.7° even if $\frac{\theta}{2}$) (1) Accept answers in radians i.e. 0.133 and 0.269 Difference = 0.136 [rad]	1 1	1 1		4	4	
	(c)	Realisation of small angles approximation **ecf** or $d\sin3.9$ **ecf** = λ(1) 125 lines per mm (1) **accept** 127 or 128		2		2	2	
		Question total	**5**	**4**	**0**	**9**	**7**	**0**

#2

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
1	(a)		Constant phase difference [accept: relationship] (between the 2 sources) ['in phase' not enough]	1			1		
	(b)		Interference or diffraction (1) Provided evidence for wave behaviour (1) [NB. independent marks]	2			2		
	(c)	(i)	Using more than one fringe separation (1) Answer = (0.80 ± 0.03) cm (1) [Ignore s.f.]		2		2	1	2
		(ii)	Substitution into $\lambda = \frac{ay}{D}$ [or by implication] (1) Answer = 515 nm ecf from (i) (1) [accept 2 or 3 s.f.]	1	1		2	2	2
		(iii)	Fringes are less bright [so more difficult to see] (1) [not: less clear or wider; not: fewer fringes will be seen] Separation of fringes is greater [can be measured with a smaller % uncertainty] or qualified more accurate based on fringe spacing] (1)			2	2		2
			Question 1 total	**4**	**3**	**2**	**9**	**3**	**6**

#3

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
2	*(a)*		**Polarisation** Polarised – vibrations in one plane only Use polarising filters Rotate filter If polarised; intensity will change Intensity will change at intervals of 90° Wave is transverse only. **Interference** Laser light is a coherent source Use of double slits to observe pattern Description of interference pattern Constructive interference occurs when path difference = $n\lambda$ Destructive interference when path difference = (n + ½) λ Young's double slit formula quoted $y = \frac{\lambda D}{a}$ Symbols explained Wavelength can be determined AO1 – show understanding of what polarisation and interference are AO3 – evaluate what properties can be determined using polarisation and interference **5-6 marks** Comprehensive description including both polarisation and interference. *There is a sustained line of reasoning which is coherent, relevant, substantiated and logically structured.* **3-4 marks** Comprehensive description of either polarisation or interference OR limited description including both polarisation and interference. *There is a line of reasoning which is partially coherent, largely relevant, supported by some evidence and with some structure.* **1-2 marks** Limited description of either polarisation or interference. *There is a basic line of reasoning which is not coherent, largely irrelevant, supported by limited evidence and with very little structure.* **0 marks** No attempt made or no response worthy of credit.	2		4	6		6
	(b)		Advantage – Efficiency; improvements to society (1) Issue – Disposal of materials (1) Benefit of research and development given - impact on environment should always be considered before developing new materials (1)			3	3		
			Question 2 total	**2**	**0**	**7**	**9**	**0**	**6**

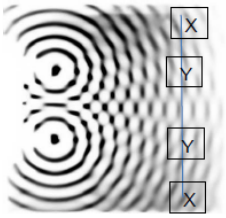
#4

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
2	*(a)*	(i)	Answer = 2a [1] Diffraction pattern is narrower / smaller central maximum / brighter [1]	2			2		
		(ii)	Make slit width approximately one wavelength or similar to one wavelength Don't accept smaller or smaller than one wavelength	1			1		
	(b)		Sound, sodium & microwaves only give interference [2] (or only 2 lasers don't) Only 1 incorrect - allow 1 mark		2		2		
	(c)		Use of equation: $n\lambda = d\sin\theta$ [1] Max possible n = 5 or min = 4 [1] λ = 600 n[m] [1] λ = 480 n[m] [1]	1	1 1 1		4	2	
			Question 2 total	**4**	**5**	**0**	**9**	**2**	**0**

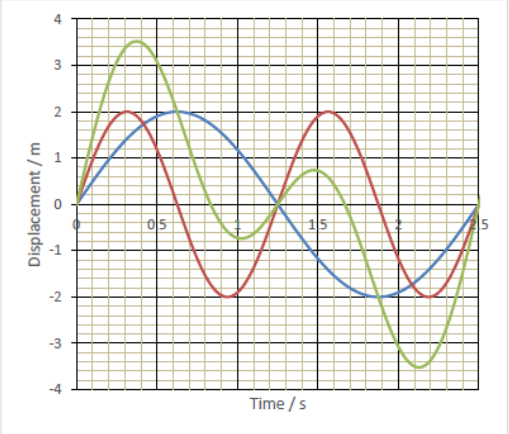
#5

Question			Marking details	Marks available AO1	AO2	AO3	Total	Maths	Prac
1	(a)		Each end has zero displacement (1) Only integers of half wavelengths can fit on string (1) As $c = f\lambda$ and speed is constant - this only occurs at particular frequencies (1) OR Waves are reflected from the fixed end (1) At particular frequencies only - arrive in phase with the next wave leaving / complete half wavelengths / nodes created (1) By principle of superposition *or* interference occurs to create nodes / antinodes (1)	3			3		
	(b)	(i)	Node to node distance = $\frac{\lambda}{2}$ (1) Wavelength = 0.24 [m] (1) Speed ($v = f\lambda$) = 108 [m s^{-1}](1)	1	1 1		3	2	
		(ii)	At 450 Hz: Length of string = $n \times 0.12$ (n = no. of loops) (1) At higher f: $(n + 2) \times 0.1$ = length of sting (1) Therefore $0.12n = 0.1\,(n + 2)$ (1) n = 10 (1)		4		4	4	
			Question 1 total	**4**	**6**	**0**	**10**	**6**	**0**

#6

Question			Marking details	Marks available AO1	AO2	AO3	Total	Maths	Prac
	(a)		Coherent sources or inphase and superposition (1) There is a path difference or waves from sources travel different distances (1) Constructive interference **and** destructive interference happens (1) Condition for constructive or destructive stated: $n \times 360$ or $n\lambda$ or $(n{+}½) \times 360$ or $(n + ½)\lambda$ (1)	4			4		
	(b)	(i) & (ii)	 (i) 1 mark (ii) 1 mark		2		2		2
	(c)	(i)	Distance of 2 or more wavelengths used (1) 0.50 – 0.70 [cm] (1)		2		2		2
		(ii)	Measuring $a = 2.9 \pm 0.2$, $\Delta y = 1.0 - 1.3$, $D = 5.2 \pm 0.1$ (note that $\frac{\Delta y}{D} \approx \frac{1}{6}$ or 0.23) (1) Making a calculation using 3 of the 4 e.g. $\lambda = \frac{2.9 \times 1.2}{5.2}$ = 0.67 [cm] (1) Evaluative comment in line with figures e.g. correct order of magnitude but not a very good approximation (1)			3	3	1	3
			Question total	**4**	**4**	**3**	**11**	**1**	**7**

#7

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
	(a)		Matter also transferred / no vibrations involved (1) So wrong (1) Accept de Broglie wavelength argument for 1 mark			2	2		
	(b)	(i)	Holes far smaller than wavelength of micro (1) So nothing passes (1) Light wavelength far smaller than 2 mm (so little or no diffraction) (1)	1 1	1		3		
		(ii)	1.6-3.3 eV or 2.56-5.28 × 10^{-19}J (or calculation leading to said numbers)	1			1		
		(iii)	Smaller because f smaller or lambda longer		1		1		
	(c)		Evidence of application of superposition e.g. 0 s (1) 0.4 and 2.1 s correct i.e. 3.4/3.6 and -3.4/-3.6 (1) 1 s and 1.5 s i.e. -0.7 and +0.7 (1) Smoothish curve through points (1)  		4		4	2	
			Question total	**3**	**6**	**2**	**11**	**2**	**0**

#8

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
	(a)	(i)	Use tan to find sin e.g. 10.23° or 0.1776 seen (1) can be implied Correct conversion of d i.e. $d = \frac{1}{300\,000}$ (1) Substitution in diffraction grating equation for n = 1 e.g. $\lambda = \frac{0.178}{300}$ Leading clearly to correct answer (1)		3		3	2	3
		(ii)	A correct percentage uncertainty i.e. 0.10 or 0.13 **OR** 0.28 or 0.3(1) Correct percentage uncertainty for tanθ (0.28 or 0.3) (1) Adding percentage uncertainties (0.38) or 0.4 or 0.41 (1) $\frac{592 \times 0.38}{100}$ or similar seen (1) NOTE: accept fractional uncertainty throughout instead of %		4		4	4	4
	(b)		Value is inside uncertainty (of both values) OR overlap region is 593-594 nm (1) Hence agreement (1)			2	2		2
	(c)		Smaller distance (same uncertainty) (1) Larger percentage/fractional uncertainty (1) Accept converse argument **if referring to n = 2 data**			2	2		2
			Question total	**0**	**7**	**4**	**11**	**6**	**11**

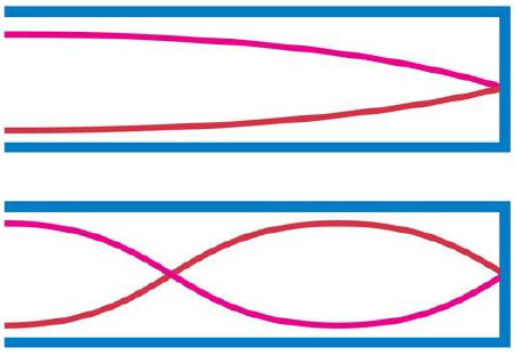
#9

Question			Marking details	Marks available AO1	AO2	AO3	Total	Maths	Prac
5	(a)		Energy - progressive carries [stationary not] or converse (1) Phase – stationary: constant in loop or successive loops in antiphase; progressive: varies with distance [or can have any value] along (1) Amplitude - antinodes & nodes or varies in stationary, constant amplitude in progressive(1)	3			3		
	(b)		$n \times \frac{\lambda}{2} = L$ (1) Multiply by the frequency or substitution: $\lambda = \frac{v}{f}$ (1) Neatly laid out algebra (1) NB.Stating $\lambda = \frac{2L}{n} \rightarrow$ no credit for 2nd mark.		3		3	2	3
	(c)		'Good agreement' on its own → 0 Straight line [with positive gradient] & good agreement (1) Lines / line of best fit [allow: mean line] pass(es) through all error bars (1) Lines straddle the origin [accept: line of best fit passes through the origin] (1)			3	3		3
	(d)		Velocity decreases (1) Gradient decreases [implied if factor < 1] (1) By factor $\sqrt{1.5}$ (1) [changes by factor $\frac{1}{\sqrt{1.5}}$ or ×0.82 - not: 25%]		3		3	1	3
	(e)		**Any sensible 2 ×(1) from:** e.g. higher concentrations (might) cause bad effects (precautionary principle) Some pedestrians suffer health effects die - respiratory problems Respiratory problems caused by other chemicals Acid rain produced by NO_2 Some pedestrians claim NO_2 bad - psychosomatic Reliable data difficult to obtain - Worse for asthma sufferers Data may be more conclusive in future Accept cheating NO_2 figures is fraud Sensible conclusion (1)			3	3		
			Question 5 total	**3**	**6**	**6**	**15**	**3**	**9**

#10

Question			Marking details	Marks available AO1	AO2	AO3	Total	Maths	Prac
	(a)	(i)	Constant phase difference/relationship	1			1		
		(ii)	Waves arrive out $\pi/180^\circ$ out of phase / in antiphase (1) Path difference will be different [for various points on the screen] (1) Path difference = $(n + \frac{1}{2})\lambda$ or $\frac{1}{2}\lambda$ and $\frac{3}{2}\lambda$ or $\frac{5}{2}\lambda$ (1)		3		3		
	(b)	(i)	Using $y = \frac{\lambda D}{a}$ (1) Fringe spacing = 17.6 [mm] (1) Attempt at $\frac{52.8}{17.6} = 3$ (1) Since whole number – a bright fringe is formed at X (1)			4	4	4	
		(ii)	Dark fringe at $\frac{y}{2}$ (1) Therefore distance = 8.8 mm **ecf unit mark** (1)		2		2		
	(c)		This experiment showed that light is a wave (1) up until this point it was thought light was made up of particles (1)	2			2		
	(d)	(i)	Electrons behave as waves **or** [beam of] electron diffracts (1) Atoms cause diffraction/interference **or** behaves like diffraction grating **or** reference to wavelength [of the beam] similar to atom spacing (1)	1	1		2		
		(ii)	Radius is greater for copper or implied by description of pattern change (1) Intensity decreases (1) Accepts stays similar	1		1	2		
			Question total	**5**	**6**	**5**	**16**	**4**	**0**

#11

Question			Marking details	Marks available AO1	AO2	AO3	Total	Maths	Prac
	(a)		 or equivalent diagrams with A & N, dots (for nodes) and double-headed arrows (for antinodes) etc.	1 1			2		2
	(b)		f = 141 [Hz] (1) λ = 2.4 [m] (1)		2		2	2	2
	(c)		Correct reference to polarised light as having vibrations (or equivalent) in one direction (1) At θ = 0 and / or 180° polaroids aligned (1) At θ = 90° polaroids crossed (1) Intermediate angles partial blocking or partial transmission or equivalent (1)	4			4		4
	(d)	(i)	When θ = 0, cos θ = 1 or $(\cos\theta)^2 = 1$ so $I = I_0$ Accept substitution of I and θ for any other value of θ		1		1	1	1
		(ii)	$(\cos 140°)^2$ = 0.587 (1) predicted I = 340 × 0.587 = 200 agreeing with graph point (1) [or $\frac{I}{I_0} = \frac{200}{340}$ = 0.588 agreeing with $(\cos 140°)^2$]	1	1		2	2	2
	(e)		More grip for smooth rubber seems to contradict (1) 4° difference but a resolution of 0.1° (accept 1°) **or** an uncertainty of <1% (1) Not random error **or** a less firm conclusion argued because more info needed about repeats (1)			3	3		3
	(f)		Valid demonstration of inverse cube, for e.g. $9.8 \times 8.0^3 = 5\,018$; $2.9 \times 12.0^3 = 5\,011$ (1) Comment: accept either "good agreement" or with reservations, such as more results needed (1)			2	2	1	2
	(g)	(i)	12.5 [m s^{-1}]		1		1		1
		(ii)	First 25 s: straight line from (0,0) to (25,12.5) **and** vertical scale (accept single label at 12.5) (1) 25 s – 30 s v continues to rise but at decreasing rate (curve) (1) 30 s – 50 s constant velocity with continuity of line at 30 s (1)		3		3	3	3
			Question total	**7**	**8**	**5**	**20**	**9**	**20**