Diffraction & Interference

Mark Scheme 3

Level	International A Level
Subject	Physics
Exam Board	CIE
Topic	Superposition
Sub Topic	Diffraction & Interference
Paper Type	Theory
Booklet	Mark Scheme 3

Time Allowed: **86 minutes**

Score: **/71**

Percentage: **/100**

A*	A	B	C	D	E	U
>85%	'77.5%	70%	62.5%	57.5%	45%	<45%

1 **(a** amplitude between 6.5 squares and 7.5 squares on 3 peaks B2
(*allow 1 mark if outside this range but between 6.0 and 8.0 squares*)
correct phase (ignore lead/lag, look at x-axis only and allow ±½ square B1 [3]

(b) $\lambda = ax / D$ C1
$540 \times 10^{-9} = (0.700 \times 10^{-3}\ x) / 2.75$ C1
$x = 2.12$ mm A1 [3]

(c) **(i)** same separation B1
bright areas brighter (1)
dark areas, no change (1)
(*allow 'contrast greater' for 1 mark if dark/light areas not discussed*)
fewer fringes observed (1) *any two, 1 each* B2 [3]

(ii) smaller separation of fringes B1
no change in brightness B1 [2]

2 **(a)** **(i)** when two (or more) waves meet (at a point) M1
there is a change in overall intensity / displacement A1
(ii) constant phase difference (between waves) B1 [3]

(b) **(i)** $d\sin\theta = n\lambda$ B1
$(10^{-3} / 550) \sin 90 = n \times 644 \times 10^{-9}$ C1
$n = 2.8$ C1
so two orders A1 [4]
(*power-of-ten error giving 2800 orders, allow 1/3 only for calculation of n*)

(ii) **1.** $d\sin\theta = n\lambda$ (*either here or in* ***(i)*** *– not both*)
θ is greater so λ is greater B1 [1]

2. when n is larger, $\Delta\theta$ is larger M1
so greater in second order A1 [2]

3	**(a)**	When a wave (front) is incident on an edge or an obstacle/slit/gap	M1		
		Wave 'bends' into the geometrical shadow/changes direction/spreads	A1	**[2]**	
	(b) (i)	$d = 1/(750 \times 10^3)$	C1		
		$= 1.33 \times 10^{-6}$ m	A1	**[2]**	
	(ii)	$1.33 \times 10^{-6} \times \sin 90° = n \times 590 \times 10^{-9}$	C1		
		$n = 2$ (must be an integer)	A1	**[2]**	
	(iii)	formula assumes no path difference of light before entering grating <u>or</u> there is a path difference before the grating	B1	**[1]**	
	(c)	e.g. lines further apart in second order lines fainter in second order (allow any sensible difference: 1 each, max 2) (if differences stated but without reference to the orders, max 1 mark)	B2	**[2]**	

4	**(a)**	When two (or more) waves meet *(not 'superpose' or 'interfere')*	B1		
		resultant <u>displacement</u>	M1		
		is the sum of individual (displacements)	A1	**[3]**	
	(b) **(i)**	any correct line through points of intersection of crests	B1		
	(ii)	any correct line through intersections of a crest and a trough	B1	**[2]**	
	(c) **(i)**	$\lambda = ax/D$ OR $\lambda = a\sin\theta$ and $\theta = x/D$	C1		
		$650 \times 10^{-9} = (a \times 0.70 \times 10^{-3})/1.2$	C1		
		$a = 1.1 \times 10^{-3}$ m	A1	**[3]**	
	(ii) **1**	no change	B1		
	2	brighter	1		
	3	no change *(accept stay/remain dark)*	B1	**[3]**	
			Total		**[11]**

5 **(a) (i)** coherence: constant phase difference between (two) waves — M1 A1 [2]

(ii) path difference is *either* λ *or* $n\lambda$
or phase difference is 360° *or* $n \times 360°$ *or* $n2\pi$ rad — B1 [1]

(iii) path difference is *either* $\lambda/2$ *or* $(n + ½)\ \lambda$
or phase difference is odd multiple of *either* 180° *or* π rad — B1 [1]

(iv) $w = \lambda D / a$ — C1
$= [630 \times 10^{-9} \times 1.5] / 0.45 \times 10^{-3}$ — C1
$= 2.1 \times 10^{-3}$ m — A [3]

(b) no change to <u>dark</u> fringes — B1
no change to separation/fringe width — B1
<u>bright</u> fringes are brighter/lighter/more intense — B1 [3]

6 **(a)** transfer / propagation of energy M1
as a result of oscillations / vibrations ..... A1 [2]

(b) (displacement / velocity / acceleration (of particles in the wave) ..... B1 [1]

(ii) displacement etc. is normal to direction of energy transfer / travel of wave / propagation of wave ……(*not 'wave motion'*) ..... B1 [1]

(iii) displacement etc. along / same direction of energy transfer / travel of wave / propagation of wave ……(*not 'wave motion'*) ..... B1 [1]

(c) diffraction: suitable object, means of observation M1
either laser *or* lamp and aperture
or distant source M1
light region where darkness expected A1

interference: suitable object, means of observation and illumination B1
light and dark fringes observed B1
appropriate reference to a dimension for diffraction or for interference ..... **B1** [6

[Total: 11]

7 **(a)** **(i)** amplitude = 0.4(0) mm A1

(i) wavelength = 7.5 x 10^{-2} m
(1 sig. fig. -1 unless already penalised) A1

(i) period = 0.225 ms C1
frequency = 1/*T* = 4400 Hz A1

(i) $v = f\lambda$
= 4400 x 7.5 x 10^{-2} C1
= 330 m s^{-1} ..... A1 [6]

(a) **(ii)** reasonable shape, same amplitude and wavelength doubled ..... B1 [1]

(b) **(i)** 1.7(2) μm A1

(ii) d sinθ = $n\lambda$ (double slit formula scores 0/2)
1.72 x 10^{-6} x sin θ = 590 x 10^{-9} C1
θ = 20.1° (allow 20°) A1

(iii) ½L = 1.5 tan20.1 ..... C1
L = 1.1 m ..... A1 [5]