## Diffraction \& Interference Mark Scheme 1

| Level | International A Level |
| :--- | :--- |
| Subject | Physics |
| Exam Board | CIE |
| Topic | Superposition |
| Sub Topic | Diffraction \& Interference |
| Paper Type | Theory |
| Booklet | Mark Scheme 1 |



1 (a difference: vibration/oscillation (of particles)/displacement of particles is parallel to energy transfer/wavefronts in longitudinal and perpendicular for transverse or transverse can be polarised, longitudinal cannot be polarised
similarity: both transfer/propagate energy
B1

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[2]
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(b) (i) waves from slits are coherent/constant phase relationship waves overlap (at screen) with a phase difference or have a path difference maxima where phase difference is integer $\times 360^{\circ}$ (or $\times 2 \pi$ rad)
or path difference is integer $\times \lambda$
or equivalent explanation of minima e.g. $(n+1 / 2) \times 360^{\circ}$
max. 2
(ii) maxima spacing $=\lambda D / a$

$$
=\left(6.3 \times 10^{-7} \times 2.5\right) / 0.35 \times 10^{-3}
$$

$$
=4.5 \times 10^{-3} \mathrm{~m}
$$

(c) (ultra-violet has) shorter wavelength, hence smaller separation/distance

2 (a) waves from the double slit are coherent/constant phase difference
waves (from each slit) overlap/superpose/meet (not interfere)
maximum /bright fringe where path cifference is $n \lambda$
or phase difference is $n 360^{\circ} / 2 \pi n$ rad
or minimum/dark fringe where path difference is $\left(n+\frac{1}{2}\right) \lambda$
or phase difference is $(2 n+1) 180^{\circ} /(2 n+1) \pi \mathrm{rad}$
(b) $v=f \lambda$
$\lambda=\left(3 \times 10^{8}\right) / 670 \times 10^{12}=448($ or 450$)(\mathrm{nm}) \quad$ M1
C1
(c) $w=12 / 9 \quad$ C1
$a(=D \lambda / w)=\left(2.8 \times 450 \times 10^{-9}\right) /\left(12 / 9 \times 10^{-3}\right) \quad$ [allow $\left.\mathrm{nm}, \mathrm{mm}\right] \quad \mathrm{C} 1$

$$
=9.5 \times 10^{-4} \mathrm{~m} \quad\left[9.4 \times 10^{-4} \mathrm{~m} \text { using } \lambda=448 \mathrm{~nm}\right]
$$

A1
(d) (red light has) larger/higher/longer wavelength (must be comparison)

3 (a waves overlap / meet / superpose
coherence / constant phase difference (not constant $\lambda$ or frequency)
(B1)
(B1)
path difference $=0, \lambda, 2 \lambda$ or phase difference $=0,2 \pi, 4 \pi$
same direction of polarisation/unpolarised
(B1) max. 3
(b) $\lambda=v / f$

C1
$f=12 \times 10^{9} \mathrm{~Hz}$
$\lambda=3 \times 10^{8} / 12 \times 10^{9}$ (any subject) M1
$=0.025 \mathrm{~m}$
A0
(c) maximum at $P$

B1
several minima or maxima between $O$ and $P$ B1
5 maxima / 6 minima between $O$ and $P$ or 7 maxima / 6 minima including $O$ and $P$
(d) slits made narrower

B1
slits put closer together
B1
(not just 'make slits smaller')
Allow tilting the slits M1 and explanation of axes of rotation A1

4 (a waves pass through the elements / gaps / slits in the grating
M1
spread into geometric shadow
A1
(b) (i) 1. displacements add to give resultant displacement

B1
each wavelength travels the same path difference or are in phase B1 hence produce a maximum A0
2. to obtain a maximum the path difference must be $\lambda$ or phase difference $360^{\circ} / 2 \pi \mathrm{rad}$B1
$\lambda$ of red and blue are different B1
hence maxima at different angles / positions A0
(ii) $n \lambda=d \sin \theta \quad$ C1
$N=\sin 61^{\circ} /\left(2 \times 625 \times 10^{-9}\right)=7.0 \times 10^{5} \quad$ A1
(iii) $n \lambda=2 \times 625$ is a constant (1250)
$n=1 \rightarrow \lambda=1250$ outside visible
$n=3 \rightarrow \lambda=417$ in visible
$n=4 \rightarrow \lambda=312.5$ outside visible
$\lambda=420 \mathrm{~nm}$
$\begin{array}{ll}\text { (a) (i) coherence: } \begin{array}{l}\text { constant phase difference } \\ \text { between (two) waves }\end{array} & \text { M1 } \\ \text { A1 }\end{array}$
(ii) path difference is either $\lambda$ or $n \lambda$
or phase difference is $360^{\circ}$ or $n \times 360^{\circ}$ or $n 2 \pi$ rad B1
(iii) path difference is either $\lambda / 2$ or $(n+1 / 2) \lambda$
or phase difference is odd multiple of either $180^{\circ}$ or $\pi \mathrm{rad} \quad$ B1 C1

$$
\text { (iv) } \begin{aligned}
w & =\lambda D / a \\
& =\left[630 \times 10^{-9} \times 1.5\right] / 0.45 \times 10^{-3} \\
& =2.1 \times 10^{-3} \mathrm{~m}
\end{aligned}
$$

$2.1 \times 10^{-3} \mathrm{~m} . \mathrm{A}$
(b) no change to dark fringes B1
no change to separation/fringe width B1
bright fringes are brighter/lighter/more intense B1
$\square$
are
B1

6 (a) (i) diffraction bending/spreading of light at edge/slit
this occurs at each slit
(ii) constant phase difference between each of the waves
(iii) (when the waves meet) the resultant displacement is the sum of the
displacements of each wave B1 B1

B1
B1
(b) $d \sin \theta=n \lambda$
$n=d / \lambda=1 / 450 \times 103 \times 630 \times 10^{-9}$
C1
$n=3.52$
M1
hence number of orders $=3$
A1
(c) $\lambda$ blue is less than $\lambda$ red $\quad \mathrm{M} 1$
more orders seen A1
each order is at a smaller angle than for the equivalent red A1

7 (a when waves overlap / meet, (resultant) displacement is the sum of the individual displacements
(b) (i) two (ball-type) dippers
connected to the same vibrating source /motor or one wave source described with two slits
$\begin{array}{ll}\text { (ii) lamp with viewing screen on opposite side of tank } & \text { B1 } \\ \text { means of freezing picture e.g. strobe } & \text { B1 }\end{array}$
(c) (i) two correct lines labelled $X$
(ii) correct line labelled $N$

