Assessment Schedule 2008

Scholarship Physics (93103)

Evidence Statement

Question	Evidence	1-4 marks	5-6 marks	7-8 marks
1(a)	The dark lines correspond to light that has the correct energy to excite transitions between the quantised energy levels of electrons of the atoms (or molecules) in the gas. The light is absorbed by the gas and re-emitted (in all directions), and so there is a strong dip in the intensity of the spectrum at these energies, causing dark lines.	Shows some understanding of the underlying physics. AND / OR (partially) correct mathematical solution to given problem.	A reasonable understanding of the underlying physics. AND (partially) correct mathematical solution to given problem.	Thorough understanding of the underlying physics. AND Correct mathematical solution to the given problem.
(b)	Diffraction illustrates the wave aspect of light. Diffraction is the spreading out of a wavefront when passing through a gap or obstacle. The wavefront acts a series of secondary sources. A stream of particles passing through a gap would not spread out in this manner. Light striking a metal surface can lead to emission of an electron. That electron's maximum energy is directly related to the frequency of the incident light and not the intensity.			

<table>
<tr>
<td>2 (a)</td>
<td>$d \sin \theta = n \lambda$
$d = \dfrac{587.563 \times 10^{-9}}{\sin 20.6426}$
$d = 1.66 \times 10^{-6}$ m

Number of lines per cm = 6 000</td>
<td rowspan="2">Shows some understanding of the underlying physics.

AND/OR

(Partially) correct mathematical solution to given problem.</td>
<td rowspan="2">A reasonable understanding of the underlying physics.

AND

(Partially) correct mathematical solution to given problem.</td>
<td rowspan="2">Thorough understanding of the underlying physics.

AND

Correct mathematical solution to the given problem.</td>
</tr>
<tr>
<td>(b)</td>
<td>The stellar wavelength is longer than the lab wavelength. Sources moving away from an observer have the wavelength of any emitted radiation increased; we say “red shifted” (since red is the largest observable visible wavelength). So the two wavelengths are different because the stellar source is moving radially away from the Earth.</td>
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<table>
<tr><th>Q</th><th>Evidence</th><th>1–4
Below Schol</th><th>5–6
Scholarship</th><th>7–8
Outstanding</th></tr>
<tr><td>3 (a)</td><td>The sources must have:
1) the same wavelength
2) fixed phase difference
3) a separation, d, greater than the wavelength
4) comparable amplitudes.</td><td rowspan="5">Thorough understanding of these applications of physics.

OR

Partially correct mathematical solution to the given problems.

AND / OR

Partial understanding of these applications of physics.</td><td rowspan="5">(Partially) correct mathematical solution to the given problems.

AND / OR

Reasonably thorough understanding of these applications of physics.</td><td rowspan="5">Correct mathematical solution to the given problems.

AND

Thorough understanding of these applications of physics</td></tr>
<tr><td>(b)</td><td>By realising that a rotation of φ for the slits will produce the standard interference pattern. The zero of intensity will be when $\frac{\lambda}{2} = d\sin\varphi$.
Answer = 0.18134 degrees</td></tr>
<tr><td>(c)</td><td>At this point there is no path difference so the only factor is the reflection phase change, and since this is 180 degrees, the two waves cancel, leading to a dark fringe.</td></tr>
<tr><td>(d)</td><td>$\theta = \frac{t}{x}$
$n = \frac{2t}{\lambda}$
$\frac{n}{x} = \frac{2\theta}{\lambda}$
Answer approx. 1270 lines per m. or 1300 to 2 sig fig.</td></tr>
<tr><td>(e)</td><td>The lines become so close together that they are unresolvable.</td></tr>
</table>

Q	Evidence	1-4 marks	5-6 marks	7-8 marks
4 (a)	The fringes from the grating would be brighter and sharper. The fringes will be brighter, having contributions from every slit in the grating. The fringes will be sharper because the destructive interference between the bright fringes will be greater (than in the double slit case). The fringes will have the same separation in both cases.	Thorough understanding of these applications of physics. OR Partially correct mathematical solution to the given problems. AND / OR Partial understanding of these applications of physics.	(Partially) correct mathematical solution to the given problems. AND / OR Reasonably thorough understanding of these applications of physics.	Correct mathematical solution to the given problems. AND Thorough understanding of these applications of physics.
(b)	The separation of the fringes will become smaller. The wavelength of the light will reduce, as its velocity has decreased while the frequency has remained constant. With reduced wavelength, a smaller displacement is needed for the interfering waves to find positions of constructive interference.			
(c)	The light through the top slit is slowed down for a while and so is out of phase with the bottom slit light when at the original position of the central maximum. The position on the screen where the two rays will be in phase must have the bottom slit light move through more phases (travel further) to realign the phases. This happens at some position up the screen.			
(d)	The ray from the uncovered slit must travel an extra 5λ to compensate for the extra phase difference introduced by the thin film. That extra pd is the number of wavelengths travelled through the material – the number of wavelengths travelled through the same distance in air. $\frac{t}{\lambda_m} - \frac{t}{\lambda_a} = 5$ $\lambda_m = \frac{\lambda_a}{n}$ $1.6t - t = 5\lambda_a$ $t = \frac{5}{0.6} \times 500 \times 10^{-9} = 4.17 \times 10^{-6}$ m t is the distance travelled; therefore the thickness of the slice will be $\leq t$.			
(e)	With monochromatic light, the zero order fringe is not obviously different from other fringes. With white light rather than monochromatic, the zero order fringe will be obviously white while the others will be variously coloured. There will be a white central maximum flanked by overlapping coloured fringes.			

<table>
<tr><th>Question</th><th>Evidence</th><th>1-4 marks</th><th>5-6 marks</th><th>7-8 marks</th></tr>
<tr><td>FIVE
(a)</td><td>Diffraction: A slit about the same size as the wavelength is needed to get maximum diffraction.

Interference: If the slits are close enough for the diffracted waves to overlap, then they will interfere.
d should be more than the wavelength.
The waves should have the same frequency, amplitude and phase difference (coherence).</td><td rowspan="4">Shows some understanding of the underlying physics

And/or

(partially) correct mathematical solution to given problem</td><td rowspan="4">A reasonable understanding of the underlying physics

And

(partially) correct mathematical solution to given problem</td><td rowspan="4">Thorough understanding of the underlying physics

And

Correct mathematical solution to the given problem</td></tr>
<tr><td>(b)</td><td>$n\lambda = \frac{dx}{L}$ is based on the assumption that $\tan\theta$ is of the order of $\sin\theta$ which is true only for small but not for large angles. $n\lambda = d\sin\theta$ is valid for angles up to 90 degrees. Both these are derived on the basis that $L >> d$.</td></tr>
<tr><td>(c)</td><td>$x << L$ therefore $(2-0.5)\lambda = \frac{dx}{L}$
$d = 2 \times 10^{-5}$ m
$L = 1.20$ m
$\lambda = 632 \times 10^{-9}$ m

$x = 5.69$ cm</td></tr>
<tr><td>(d)</td><td>$n\lambda = d\sin\theta = 1380$nm from data given.

Therefore n and λ are (for red) $n = 2$ and $\lambda = 690$ nm
For blue / violet $n = 3$ and $\lambda = 460$ nm

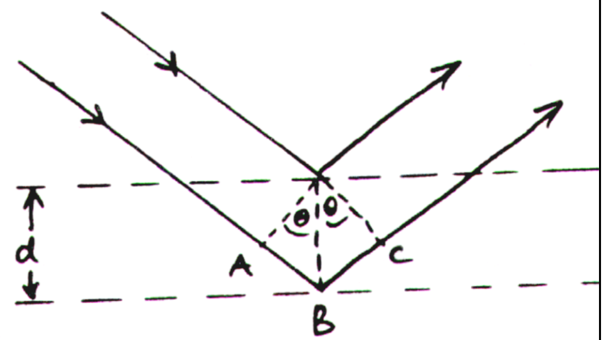
For realistic values, $n\lambda$ must be less than sin90 = 3333 nm.

The only other pair of integers which are in the ratio $3m : 2m$ with m less than $\frac{3333}{1380}$ (= 2.4) is 6 : 4.

Therefore there is only one more pattern in the range 0 to 90 given by
$\sin\theta = \frac{6 \times 460}{3333}$
$\theta = 55.9°$

Yes. Only one at 55.90°.</td></tr>
</table>

Question	Mark Allocation	Typical evidence
6(a)	1 mark for path difference. 1 mark for constructive/ destructive interference description.	The path lengths that the two beams follow to the receiver will change in length as the receiver moves. When the two path lengths differ by a whole number of wavelengths, constructive interference (high intensity) will occur. When the two path lengths differ by an odd number of ½ wavelengths, destructive interference (low intensity) will occur.
4 (b)	2 marks for correct statement.	Given that there is no phase change on reflection, both beams will arrive having travelled the same distance, and therefore will arrive in phase, resulting in constructive interference.
4 (c)	2 marks for solution as shown or equivalent involving a correct expression for the path difference.	By considering the situation shown, it can be seen that effectively there is a virtual source at position 'a' below the desk. Assuming the angles are small, this is analogous to Young's two slit experiment where $n\lambda = d\sin\theta = \frac{dx}{L}$ (small angle approximation) and $\sin\theta = \frac{y}{s}$ $n\lambda = \frac{dx}{L} = \frac{2ay}{s}$
4 (d)	2 marks for correct statement.	The reflection of light at a hard surface causes a phase reversal. This means the two waves interfering have opposite phase, and so destructive interference takes place.

Question	Type 1 (explanatory) or Type 2 (problem)	B Evidence	A Evidence
7(ii)	2		 The extra path difference for the lower ray relative to the upper ray is AB + BC =2AB but AB/d = sinθ Therefore for a maximum in the reflected intensity at angle θ the path difference must be an integral number of wavelengths $m\lambda = 2d\sin\theta \quad m = 1, 2, 3, ...$
(iii)	2		$3\text{rd order} \Rightarrow m = 3$ $\theta = \frac{29.2°}{2} = 14.6°$ $\lambda = 1.27 \times 10^{-10}$ m $d = \frac{m\lambda}{2\sin\theta} = \frac{3 \times 1.27 \times 10^{-10}}{2 \times \sin 14.6°}$ $= 7.56 \times 10^{-10}$ m

Question	Type 1 (explanatory) or Type 2 (problem)	B Evidence	A Evidence
(iv)	1	Candidates recognised that the wavelength of light was too large for interference.	Visible light has a wavelength of about 5000×10^{-10} m, which is too large for interference to be observed from adjacent planes. Mention will be made of diffraction and the necessary condition that wavelength should approximately be of the order of the plane spacing.