Neap:

PHYSICS VCE UNITS 3&4
DIAGNOSTIC TOPIC TESTS 2017

TEST 8: HOW CAN WAVES EXPLAIN THE BEHAVIOUR OF LIGHT? (II)

SUGGESTED SOLUTIONS AND MARKING SCHEME

Question 1 (5 marks)

a. Light is an electromagnetic transverse wave which has oscillations in all orientations as it travels along its axis. 1 mark

The polariser atoms interact with light so that only oscillations in a single plane are transmitted through it. 1 mark

b. Light has wave components which oscillate in the vertical dimension and the rest which oscillate in the horizontal dimension. 1 mark

For there to be no light passing through the system of two polarisers, both sets of vertical and horizontal components have been blocked or absorbed. 1 mark

Thus the polarising lines of the polarisers must be at right angles to each other for this to occur. 1 mark

Question 2 (6 marks)

a. Dispersion is the separation of white light into its colours by the process of refraction. 1 mark
Refraction occurs when light passes from one material into another and changes its speed and direction. 1 mark
The ability of a material to refract light increases as does the frequency of the colour of light causing different colours to travel in slightly different directions. 1 mark

b. to test if green light itself can be dispersed into different colours. 1 mark

c. The green light did not disperse 1 mark
indicating that it consists only of green light. 1 mark

Question 3 (9 marks)

a. $n_1 \sin\theta_1 = n_2 \sin\theta_2$

$1.85 \times \sin(40) = n_2 \times \sin(60)$ 1 mark

$n_2 = \dfrac{1.85 \times 0.6428}{0.8660}$

$= 1.37$ 1 mark

b. $v_1 = \dfrac{c}{n_1}$

$= \dfrac{3.00 \times 10^8}{1.85}$ 1 mark

$= 1.62 \times 10^8 \text{ m s}^{-1}$ 1 mark

Subtract 1 mark if not expressed to three significant figures.

c. If light can pass into medium 2, then an angle can be calculated.

$n_1 \sin\theta_1 = n_2 \sin\theta_2$ can be used or a critical angle can be calculated.

$i_c = \sin^{-1}\left(\dfrac{n_2}{n_1}\right)$

$i_c = \sin^{-1}\left(\dfrac{1.37}{1.85}\right)$ 1 mark

$i_c = 48°$ 1 mark

Thus 48° is the largest angle of incidence that will enable light to refract into medium 2. 1 mark

Since 55° is greater than the largest permissible angle of refraction, the light does not refract into medium 2. 1 mark

It reflects away at the boundary between the two media according to the law of reflection. 1 mark

*Note: Consequential on answer to **Question 3a.***

Question 4 (6 marks)

a. Since the laser light only refracts for incident angles less than 63°, light must deviate away from the normal as it passes from formazin into the glass. 1 mark

Thus the glass must be of a lesser refractive index than that of the formazin. 1 mark

b. Since the maximum angle of incidence is 63°,

$n_{\text{formazin}} \times \sin(i) = n_{\text{glass}} \times \sin(90)$

$1.85 \times \sin(63) = n_{\text{glass}}$ 1 mark

$n_{\text{glass}} = 1.85 \times 0.8910$

$= 1.65$ 1 mark

c. Since the angle of incidence is greater than the critical angle for light travelling from formazin to glass, it will totally internally reflect, 1 mark
and so refraction, and therefore dispersion cannot occur. 1 mark

Question 5 (19 marks)

a. The light waves from the two slits are in phase and spread out in front of the two slits. 1 mark
The waves interfere with each other such that when a crest or trough from each slit meet, 1 mark
the resultant constructive interference forms a bright band.

Constructive interference occurs when the difference in the paths travelled by the interfering wave sections is 0 or a whole number of wavelengths. 1 mark
path difference = 0, 1λ, 2λ, 3λ…

When a crest from a slit and trough from the other slit meet, the resultant destructive interference forms a dark band. 1 mark

Destructive interference occurs when the difference in the paths travelled by the interfering wave sections is a whole number plus $\frac{1}{2}$ of a wavelength.
path difference = $\frac{1}{2}\lambda$, $1\frac{1}{2}\lambda$, $2\frac{1}{2}\lambda$… 1 mark

b. The bands are closer together in the new pattern and the distance between the bands, Δx, is such that $\Delta x \propto \frac{\lambda L}{d}$. 1 mark

Either L is decreased or 1 mark
d is increased. 1 mark

c. distance (S_1 B) – distance (S_2 B) = $1\frac{1}{2}\lambda$ (second dark band – destructive interference) 1 mark

distance (S_1 B) – $3.500 \times 10^{-5} = 1\frac{1}{2} \times 6.0 \times 10^{-7}$

distance (S_1 B) = $3.500 \times 10^{-5} + 9.0 \times 10^{-7}$ 1 mark

distance (S_1 B) = 3.590×10^{-5} m 1 mark

d. distance (S_2 A) – distance (S_1 A) = 2λ (second bright band – constructive interference) 1 mark

3.800×10^{-5} – distance (S_1 A) = $2 \times 6.0 \times 10^{-7}$

distance (S_1 B) = $3.500 \times 10^{-5} + 1.2 \times 10^{-6}$ 1 mark

distance (S_1 B) = 3.620×10^{-5} m 1 mark

e. If the light propagating from the two slits is considered to be a stream of balls, then the balls from each slit would strike one band on the screen, mainly directly opposite each slit. 1 mark

This would result in two bright bands being observed generally directly opposite the two slits. 1 mark

f. The production of a bright band occurs when two balls collide and the determination of the resulting energy is an additive process. 1 mark

The production of a dark band cannot be explained because the particle model is not able to account for the cancellation of energies of two balls as they strike 1 mark
since the collision between two balls is an additive process for the resulting energy. 1 mark