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

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

$$= 1.37$$ 1 mark

**b.**

$$v_1 = \frac{c}{n_1}$$

$$= \frac{3.00 \times 10^8}{1.85}$$ 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.

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

$$i_c = \sin^{-1}\left(\frac{1.37}{1.85}\right)$$ 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, the resultant constructive interference forms a bright band. 1 mark

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 = $0, 1\lambda, 2\lambda, 3\lambda\ldots$

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 = $\frac{1}{2}\lambda, 1\frac{1}{2}\lambda, 2\frac{1}{2}\lambda\ldots$ 1 mark

**b.** The bands are closer together in the new pattern and the distance between the bands, $\Delta x$, 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) = $3.590 \times 10^{-5}$ m 1 mark

**d.** distance ($S_2$ A) – distance ($S_1$ A) = $2\lambda$ (second bright band – constructive interference) 1 mark

$3.800 \times 10^{-5}$ – 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) = $3.620 \times 10^{-5}$ 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