Validation

NAME: .... SOLUTIONS ....

Total Marks: 34 *Time Allowed: 45 minutes*

(Formula sheet, research notes and scientific calculator permitted)

Question 1 **(8 marks)**

In a double-slit experiment, Anna uses blue light of wavelength 465 nm, a slit separation of 0.0400 cm and a slit-screen distance of 55.0 cm.

(a) How many bright bands will Anna see inside the central 10.0 cm of the screen? [5]

$$\lambda = \frac{xd}{nL}$$

$$465 \times 10^{-9} = \frac{0.05 \times 0.04 \times 10^{-2}}{n \times 0.55}$$ ✓✓✓

$$\therefore n \approx 78.2$$ ✓

$$\therefore \text{N° bands} = 2 \times 78 + 1$$
$$= \underline{157}$$ ✓

5

Consider the line perpendicular to the screen and joining the middle of the screen to the midpoint between the slits.

(b) At what angle (in degrees) to this line would Anna see the 3rd-order fringe? [3]

$$\lambda = \frac{d \sin\theta}{n}$$

$$465 \times 10^{-9} = \frac{0.04 \times 10^{-2} \sin\theta}{3}$$ ✓✓

$$\therefore \theta \approx \underline{0.200°}$$ ✓

3

8

Question 2

(9 marks)

Brock is conducting a two-slit experiment in which he fires electrons at the slits at a speed of 7.90×10^6 ms^{-1}.

(a) If electrons are particles, what should he see on the screen? [1]

Two parallel lines only, the same distance apart as the slits. ✓

1

(b) What will he actually see on the screen, and what does it suggest about the nature of electrons? [2]

a large no. of fringes around a (bright) central fringe. ✓

This is the same as a wave interference pattern, so suggests that electrons have a wave nature. ✓

2

(c) What is the de Broglie wavelength of the electrons? [3]

$$\lambda = \frac{h}{p} = \frac{h}{mv} \checkmark$$

$$= \frac{6.63 \times 10^{-34}}{9.11 \times 10^{-31} \times 7.9 \times 10^{6}} \checkmark$$

$$\approx \underline{9.21 \times 10^{-11} \text{ m}} \checkmark$$

3

(d) How far from the central fringe is a 5th-order fringe if the screen distance is 1.00×10^4 times the slit width? [3]

$$\lambda = \frac{xd}{nL}$$

$$9.21 \times 10^{-11} = \frac{x}{5} \times \frac{1}{1 \times 10^4} \checkmark\checkmark$$

$$\therefore x \approx \underline{4.61 \times 10^{-6} \text{ m}} \checkmark$$

3

9

Question 3

(7 marks)

A certain type of glass has a refractive index 1.52. A yellow light ray of wavelength 582 nm enters the glass (from air). Find the ray's

(a) frequency in the glass, [3]

$$f_{air} = \frac{v}{\lambda} = \frac{3 \times 10^8}{582 \times 10^{-9}}$$ ✓

$$\approx 5.15 \times 10^{14} \text{ Hz}$$ ✓

$$\therefore f_{glass} = \underline{5.15 \times 10^{14} \text{ Hz}}$$ ✓

3

(b) speed in the glass, [2]

$$n = \frac{c}{v}$$

$$\Rightarrow v_{glass} = \frac{c}{n} = \frac{3 \times 10^8}{1.52}$$ ✓

$$\approx \underline{1.97 \times 10^8 \text{ ms}^{-1}}$$ ✓

2

(c) wavelength in the glass. [2]

$$\lambda_{glass} = \frac{v_{glass}}{f_{glass}}$$

$$= \frac{1.97 \times 10^8}{5.15 \times 10^{14}}$$ ✓

$$\approx \underline{3.82 \times 10^{-7} \text{ m}}$$ ✓

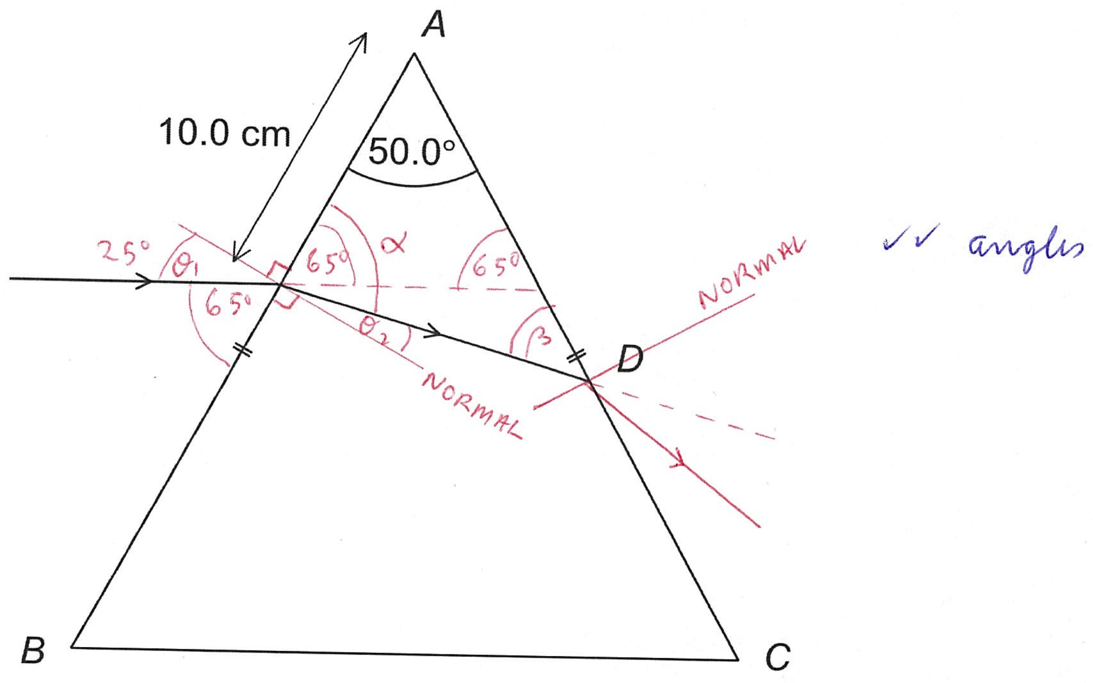
(or 382 nm)

2

7

Question 4 **(10 marks)**

The diagram below shows a ray of light in air entering an isosceles triangular glass prism parallel to the base of the prism and 10.0 cm from the apex of the prism:



The refractive index of the glass is 1.50.

(a) Find the distance *AD*. [8]

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

$1 \times \sin 25° = 1.5 \sin\theta_2$ ✓

$\therefore \theta_2 = 16.36°$ ✓

$\therefore \alpha = 90° - 16.36°$

$= 73.64°$ ✓

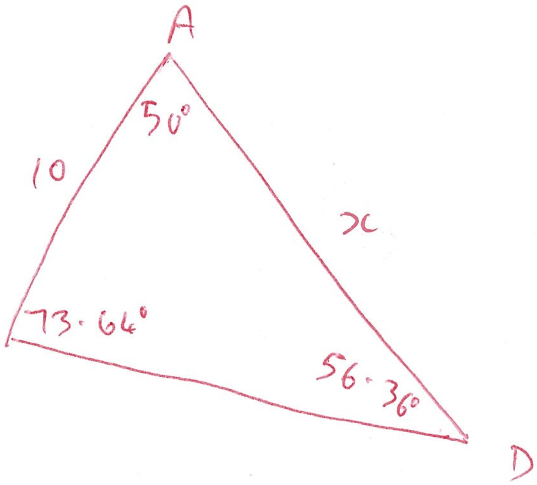
$\therefore \beta = 180° - 50° - 73.64°$

$= 56.36°$ ✓

6

/6

(More working space for part (a))



$$\frac{x}{\sin 73\cdot64^\circ} = \frac{10}{\sin 56\cdot36^\circ}$$ ✓

✓ (2)

$\therefore\ x \approx 11\cdot5$ cm

(b) Draw and label the normal at point *D*, and also draw the emerging ray from point *D*. (No calculation required.) [2]

✓✓ (2)

– End of Questions –

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