Homework exercise 6 – Polarisation

Total = 28 marks

Question 1:

A student is investigating polarisation of waves.

(a) State what is meant by *plane polarised light*. 1

(b) While doing some background reading the student discovers that the Brewster angle i_p for the liquid solvent triethylamine is given as 54·5°. Explain, using a diagram, what is meant by the Brewster angle. 2

(3)

Question 2:

Marks

A television aerial is shown in Figure 15.

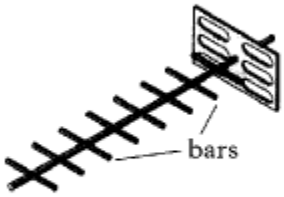

Figure 15

(*a*) Instructions for installing the aerial state

"*The television waves received are plane polarised. The aerial does not pick up a strong signal unless the plane of the bars is the same as the plane of polarisation of the television waves.*"

(i) Explain the term *plane polarised*.

(ii) The aerial is installed and connected to a television.

The television has a clear picture when the bars of the aerial are horizontal as shown in Figure 15.

The aerial is now slowly rotated until the bars are vertical as shown in Figure 16.

Describe what happens to the television picture during this rotation. **2**

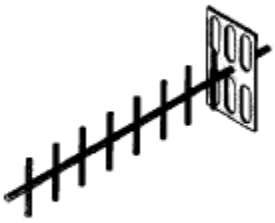

Figure 16

(*b*) Unpolarised light strikes the surface of a transparent material at the Brewster angle i_p, as shown in Figure 17. The reflected light is plane polarised.

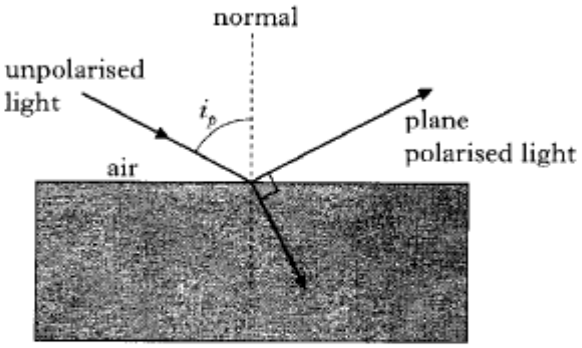

Figure 17

(i) Derive the expression

$$n = \tan i_p$$

where n is the refractive index of the transparent material.

(ii) Calculate the Brewster angle for perspex. **4**

(6)

Question 3:

Marks

11. A light source produces a beam of unpolarised light. The beam of light passes through a polarising filter called a polariser. The transmission axis of the polariser is shown in Figure 11A.

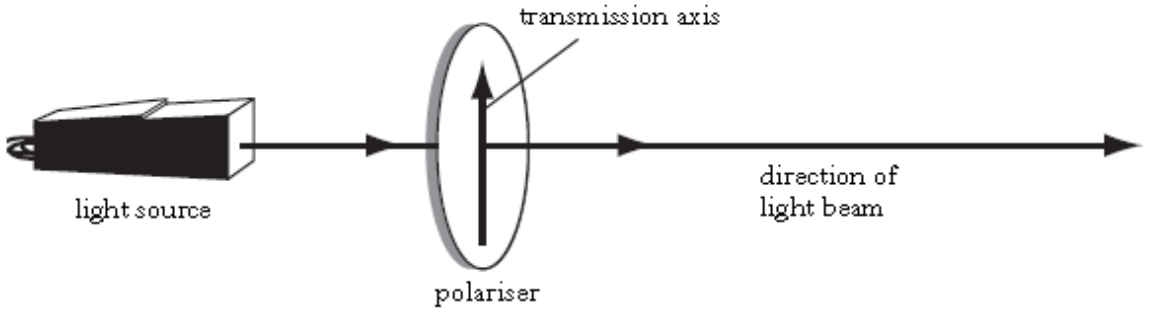

Figure 11A

(*a*) Explain the difference between the unpolarised light entering the polariser and the plane polarised light leaving the polariser. **1**

(*b*) The plane polarised light passes through a second polarising filter called an analyser.

The irradiance of the light passing through the analyser is measured by a light meter.

The transmission axis of the analyser can be rotated and its angle of rotation measured using a scale as shown in Figure 11B.

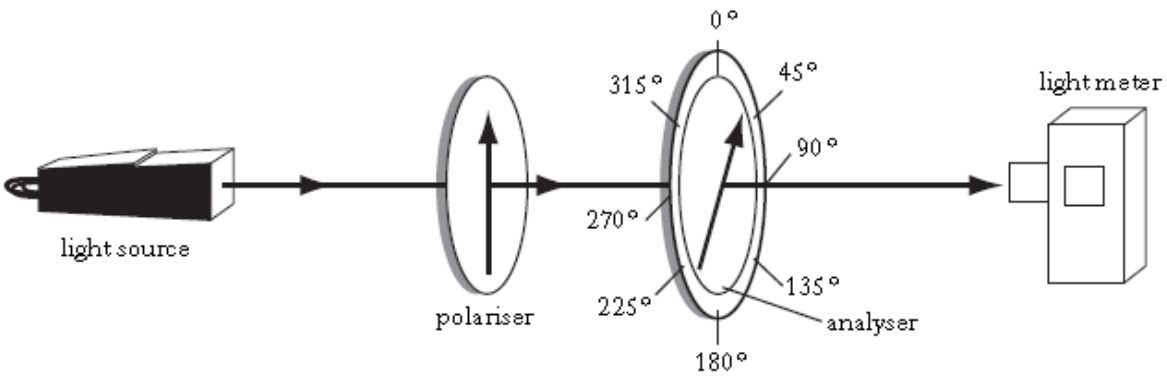

Figure 11B

(i) The analyser is rotated.

State the **two** positions on the analyser scale that will produce a maximum reading of irradiance, I_0, on the light meter. **2**

(ii) The relationship between the irradiance I detected by the light meter and the angle of rotation θ is given by

$$I = I_0 \cos^2\theta.$$

Explain how the equipment shown in Figure 11B could be used to establish this relationship.

Your answer should include:

- the measurements required;
- a description of how the relationship would be verified. **3**

(6)

Question 4:

Marks

11. (*a*) State the difference between plane polarised light and unpolarised light. **1**

(*b*) The digital display on a calculator consists of many small segments of liquid crystal material.

A "0" changes to an "8" when the middle segment switches from light to dark as shown in Figure 20.

Figure 20

To make one segment of a 7-segment display, a slice of liquid crystal is placed between a piece of polarising material and a mirror. Figure 21 shows this arrangement for the **middle segment only**.

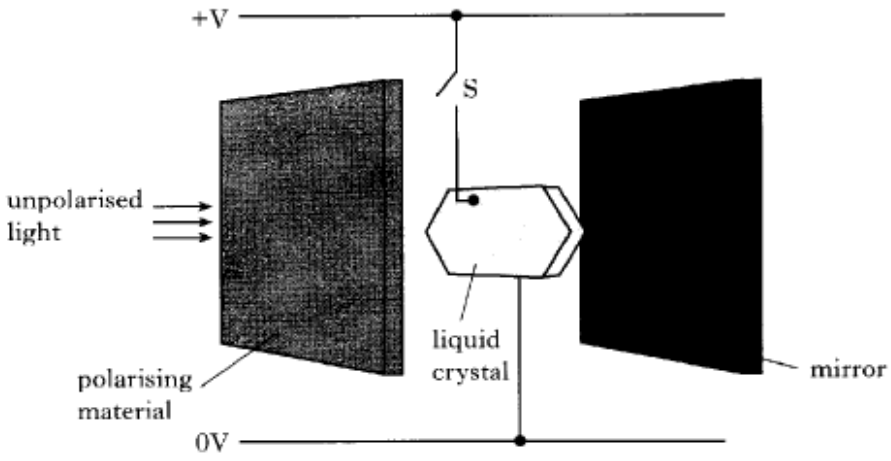

Figure 21

The following table summarises the effect of switch S.

Switch S	*Response of liquid crystal*
open	transmits polarised light
closed	does not transmit polarised light

(i) Explain why the liquid crystal appears dark when switch S is closed. **2**

(ii) State what happens to the switch when an "8" is changed to a "0". **1**

(*c*) A student sees a row of numbers displayed on a calculator through a separate piece of polarising material as shown in Figure 22.

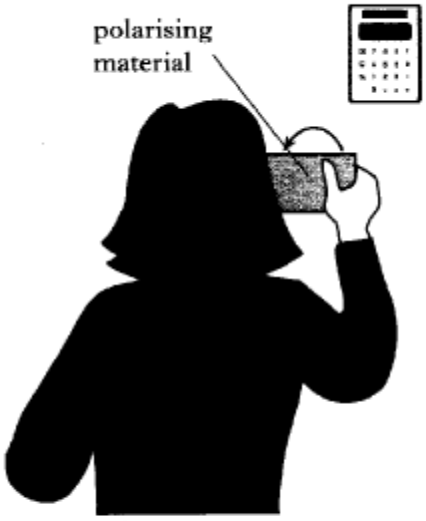

Figure 22

The student rotates the piece of polarising material through 180°. Explain what is seen as the polarising material is rotated. **2**

(6)

Question 5:

Marks

. (*a*) (i) State what is meant by the term *plane polarised light*. **1**

(ii) Figure 16 shows the refraction of red light at a water-air interface.

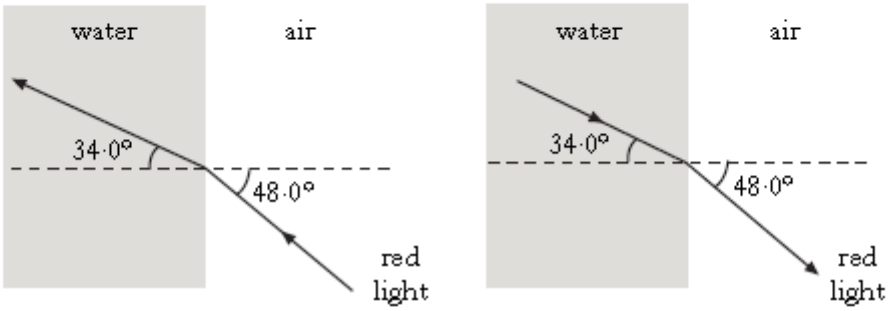

Figure 16

The refractive index n for red light travelling from air to water is 1·33. Show that the refractive index μ for red light travelling from **water** to **air** is 0·752. **1**

(iii) Figure 17 shows a ray of unpolarised red light incident on a water-air interface.

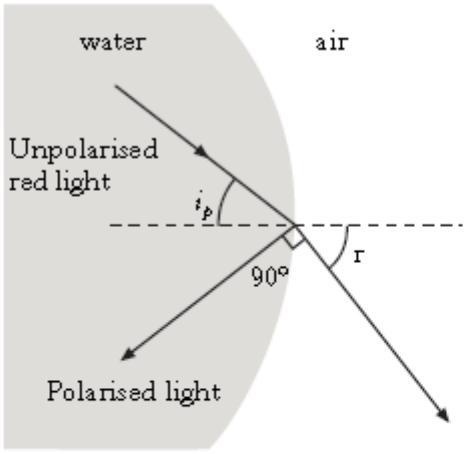

Figure 17

For light travelling from water to air,

$$\mu = \tan i_p$$

where i_p is the Brewster angle.

Calculate the Brewster angle for red light at this water-air interface. **1**

(*b*) A rainbow is produced when light follows the path in a raindrop as shown in Figure 18.

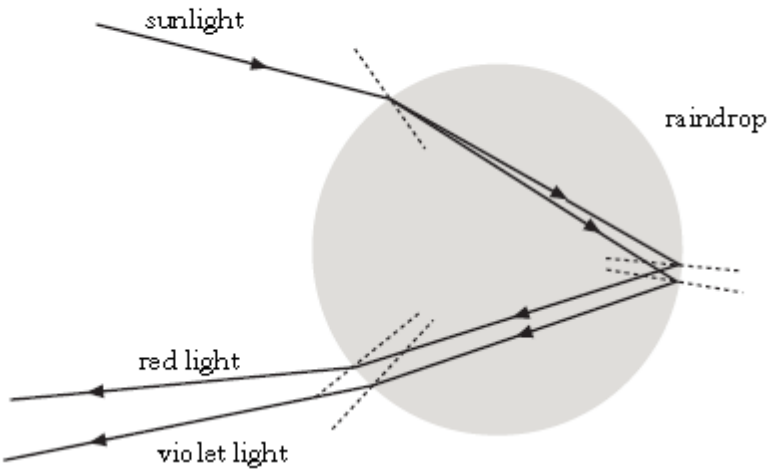

Figure 18

The light emerging from the raindrop is polarised.

The refractive index, μ, at a water to air interface is 0·752 for red light and 0·745 for violet light.

Calculate the difference in Brewster's angle for these two colours. 2

(*c*) Rainbows produce light that is 96% polarised. A photographer plans to take a photograph of a rainbow. Her camera has a polarising filter in front of the lens as shown in Figure 19.

Figure 19

She directs her camera at the rainbow and slowly rotates the filter to see which is the best image to take.

Describe what happens to the image of the rainbow as she slowly rotates her filter through 180°. 2

(7)