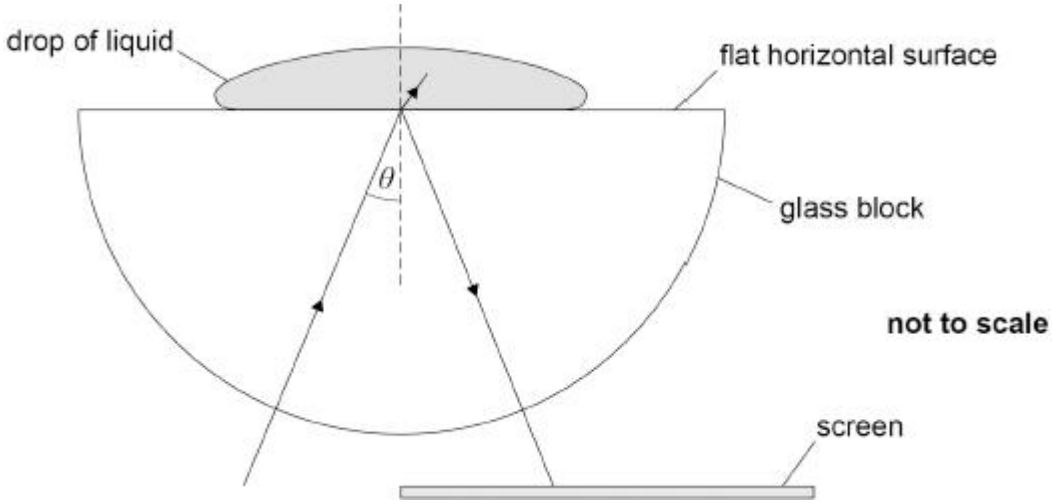
Name of the Student:_____
Max. Marks : 24 Marks **Time : 24 Minutes**

Q1.

Figure 1 shows a type of refractometer.
A semi-circular glass block is arranged so that its semi-circular faces are vertical. A drop of liquid is placed at the centre of the flat horizontal surface of the block.

Figure 1



Light enters the block through the curved surface and is incident on the midpoint of the horizontal surface at angle of incidence θ.
Light that reflects at the glass–liquid boundary is detected on a screen that lies parallel to the horizontal surface.

(a) Explain why the light ray in **Figure 1** does not change direction as it enters the block.

_____

_____

(1)

(b) The refractometer is calibrated using a drop of liquid.
When θ = 15°, light is partially refracted at the glass–liquid boundary.

Calculate the angle of refraction at this boundary.

refractive index of glass block = 1.84
refractive index of liquid = 1.33

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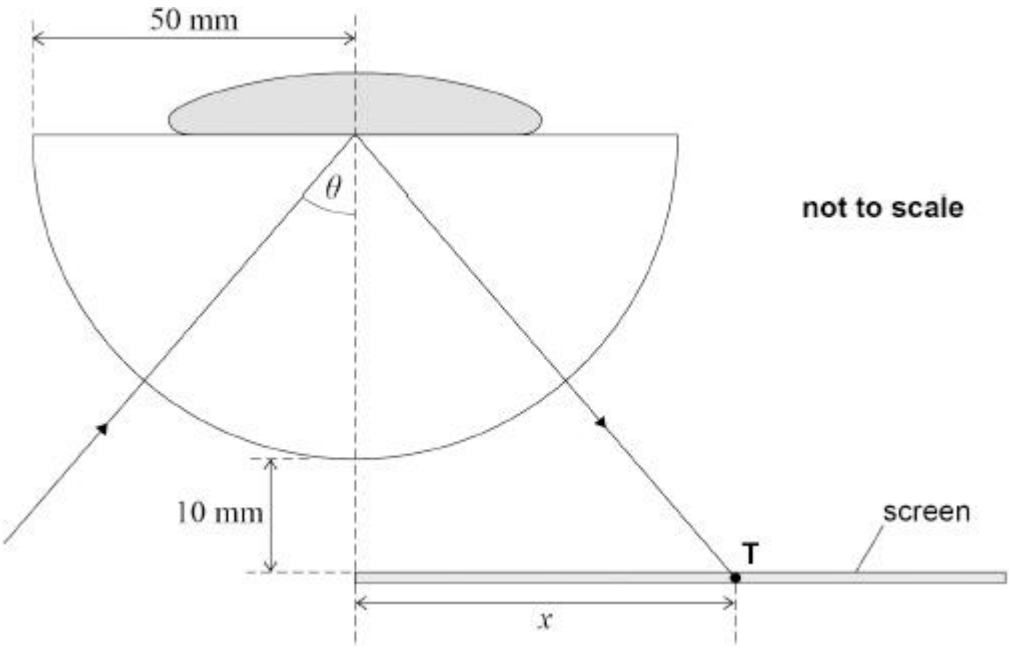
angle of refraction = _____ °

(2)

The refractometer is used to determine the critical angle θ_c at the glass–liquid boundary.

Figure 2 shows dimensions of the arrangement.

Figure 2



The intensity of the light ray on the screen is observed as θ is increased from 15°. When $\theta = \theta_c$ the intensity of the light ray is seen to increase sharply at a point **T** on the screen.

The distance between the left-hand edge of the screen and **T** is x.

(c) Explain why the intensity of the light ray on the screen increases at **T**.

_____

_____

_____

_____

(2)

(d) The liquid is replaced with a drop of sugar solution.
The refractive index of the sugar solution is greater than 1.33

Deduce how this change affects the position at which the sharp increase in intensity is observed on the screen.

_____

_____

_____

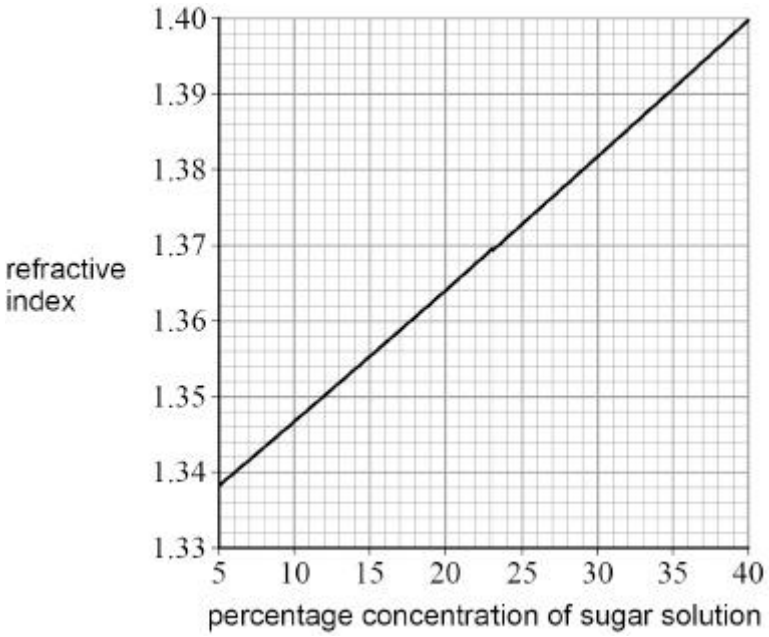
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(2)

(e) The refractometer in **Figure 2** is used to determine the concentration of a sugar solution.

Figure 3 shows the variation of refractive index with concentration of sugar solution.

Figure 3



For a drop of a particular sugar solution, x = 69 mm.

Determine the percentage concentration of the sugar solution.

refractive index of glass block = 1.84

percentage concentration = _____

(3)

(Total 10 marks)

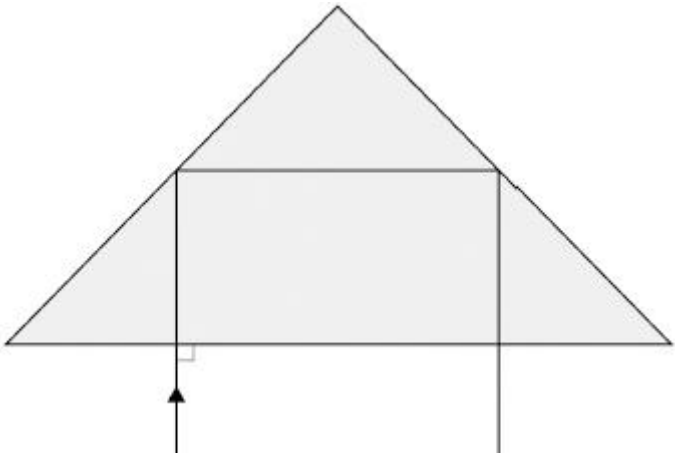
Q2.

Porro prisms are used in binoculars to reverse the path of the light. The prism is in the shape of a right-angled isosceles triangle.

Figure 1 shows a ray of light, at normal incidence on the longest side, passing through a glass Porro prism.

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Figure 1



The critical angle for light in the prism is 41.5°.

(a) Show that the glass used to make the prism has a refractive index of about 1.5

(1)

(b) Explain why the ray emerges parallel to the incident ray.

_____

_____

_____

_____

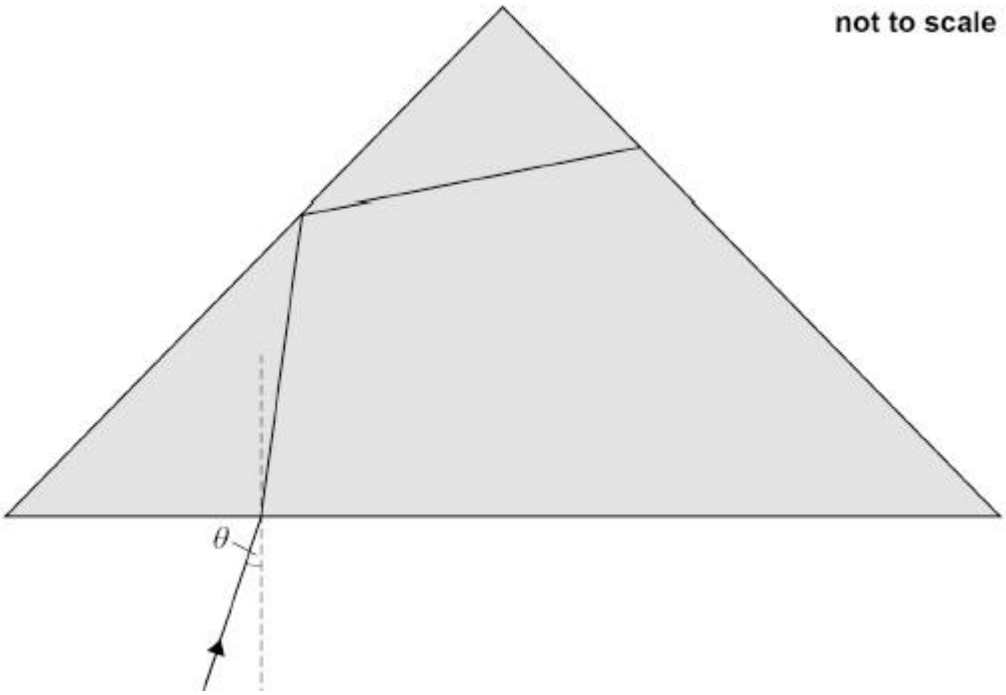
_____

(2)

Figure 2 shows a ray of light entering the prism at an angle of incidence θ and reflecting off one of the shorter sides.

Figure 2

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θ is the largest angle of incidence for which all of the light leaves through the longest side.

(c) Draw on **Figure 2** the path of the ray of light as it continues inside the prism and emerges from the longest side.

(3)

(d) When the angle of incidence is greater than θ, some of the light escapes the prism through one of the shorter sides.
Assume that the refractive index is 1.5 and the critical angle is 41.5°.

Show that θ is about 5°.
You can use **Figure 2** in your answer.

(4)

(e) A manufacturer wants to make a prism with a larger value of θ.

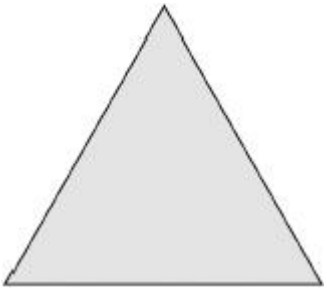
Two alternative changes to the original design of the prism are suggested:

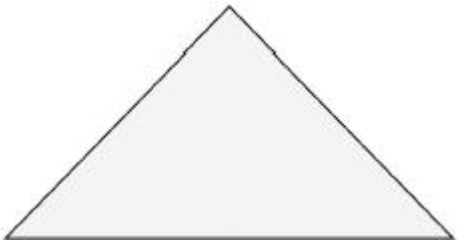
1. use a prism of the original glass in the shape of an equilateral triangle, as shown in **Figure 3**

2. use a prism of the original shape made from glass with a smaller refractive index, as shown in **Figure 4**.

Figure 3 **Figure 4**

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Discuss whether either of the two suggestions would work.

1 _____

_____

_____

_____

_____

_____

_____

2 _____

_____

_____

_____

_____

_____

_____

(4)

(Total 14 marks)

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