Selected Questions – Set 1

1.

(a) State what is meant by the *photoelectric effect*.

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.... **[1]**

(b) Explain why electrons are released from a particular metal when it is illuminated by weak blue light, but not when it is illuminated by very intense red light.

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.... **[4]**

(c) Electromagnetic waves are incident on the surface of a particular metal. Fig. 6.1 shows a graph of the maximum kinetic energy KE_{max} of the electrons released from the surface against the frequency f of the electromagnetic waves.

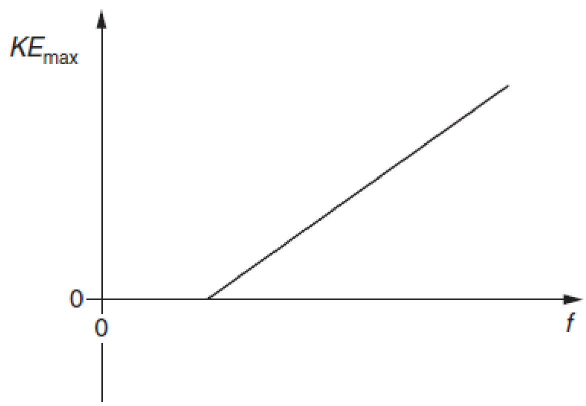

Fig. 6.1

(i) On Fig. 6.1

1 mark with a letter **F** a point corresponding to the threshold frequency of the metal **[1]**

2 mark with a letter **W** on the vertical axis a point corresponding to the work function energy of the metal. **[1]**

(ii) State and explain how the graph of Fig. 6.1 will change when a metal of higher work function energy is illuminated by electromagnetic radiation. You may support your answer by drawing on Fig. 6.1.

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.... **[3]**

(d) For a particular metal, electromagnetic radiation of frequency 1.36×10^{15} Hz incident on its surface releases electrons with a maximum kinetic energy of 5.82×10^{-19} J.

(i) Suggest why the electrons emitted from the metal have a range of kinetic energies.

....

.... **[1]**

(ii) Use Einstein's photoelectric equation to calculate

1 the work function energy of the metal

work function energy = ... J **[2]**

2 the maximum kinetic energy of the electrons when the frequency of the incident radiation is halved.

kinetic energy = ... J **[2]**

2.

When ultraviolet light of frequency 3.0×10^{15} Hz is incident on the surface of a metal, electrons of maximum kinetic energy 1.7×10^{-18} J are emitted.

(a) Explain why the emitted electrons have a range of kinetic energies up to a maximum value.

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(3 marks)

(b) (i) Show that the work function of the metal is 1.8 eV.

(3 marks)

(b) (ii) Calculate the threshold frequency of the metal. Give your answer to an appropriate number of significant figures.

threshold frequency .... Hz

(3 marks)

(c) (i) State and explain the effect on the emitted electrons of decreasing the frequency of the incident radiation whilst keeping the intensity constant.

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(2 marks)

(c) (ii) State and explain the effect on the emitted electrons of doubling the intensity of the incident radiation whilst keeping the frequency constant.

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(2 marks)

3.

Fig. 7.1 shows an electrical circuit, which includes a photocell.

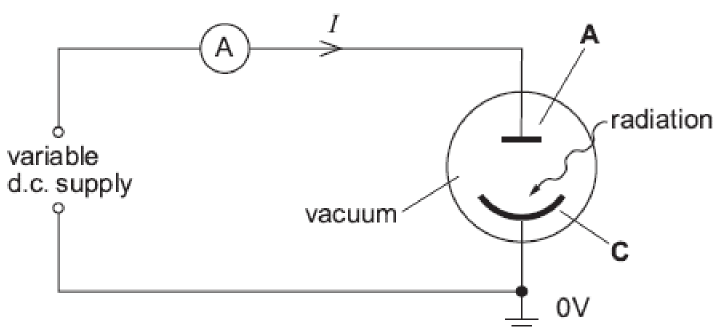

Fig. 7.1

The photocell consists of a metal plate **C** that is exposed to electromagnetic radiation. The photoelectrons emitted travel towards the electrode **A**. A sensitive ammeter measures the current in the circuit.

The plate **C** is illuminated with ultraviolet radiation of constant intensity and of wavelength 2.5×10^{-7} m. Fig. 7.2 shows how the photoelectric current I in the circuit varies with the potential difference V between **A** and **C**.

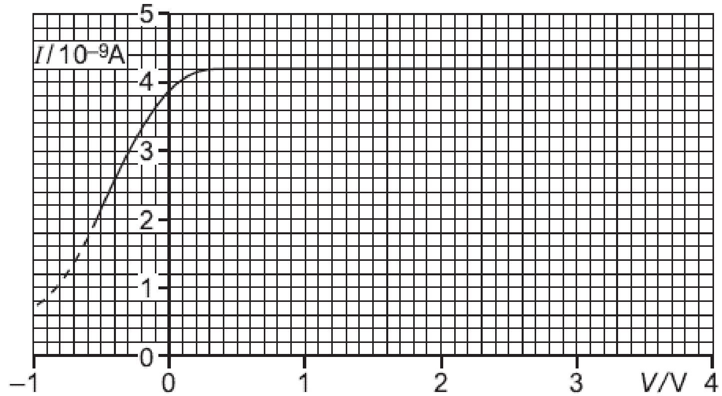

Fig. 7.2

(a) Use Fig. 7.2 to show that when the potential difference V is 2.0 V the number of electrons reaching the electrode **A** per second is $2.6 \times 10^{10}\,s^{-1}$.

[3]

(b) The metal of plate **C** has work function energy 2.2 eV. Calculate the maximum kinetic energy in joules of the emitted photoelectrons from this plate.

kinetic energy = ... J [4]

(c) **(i)** State how the maximum energy of the photoelectrons emitted from plate **C** depends on the intensity of the incident radiation.

....

....[1]

(ii) State and explain how the photoelectric current depends on the intensity of the radiation.

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....[2]

4.

Fig. 4.1 shows a graph of displacement *y* against time *t* for a point on a wave.

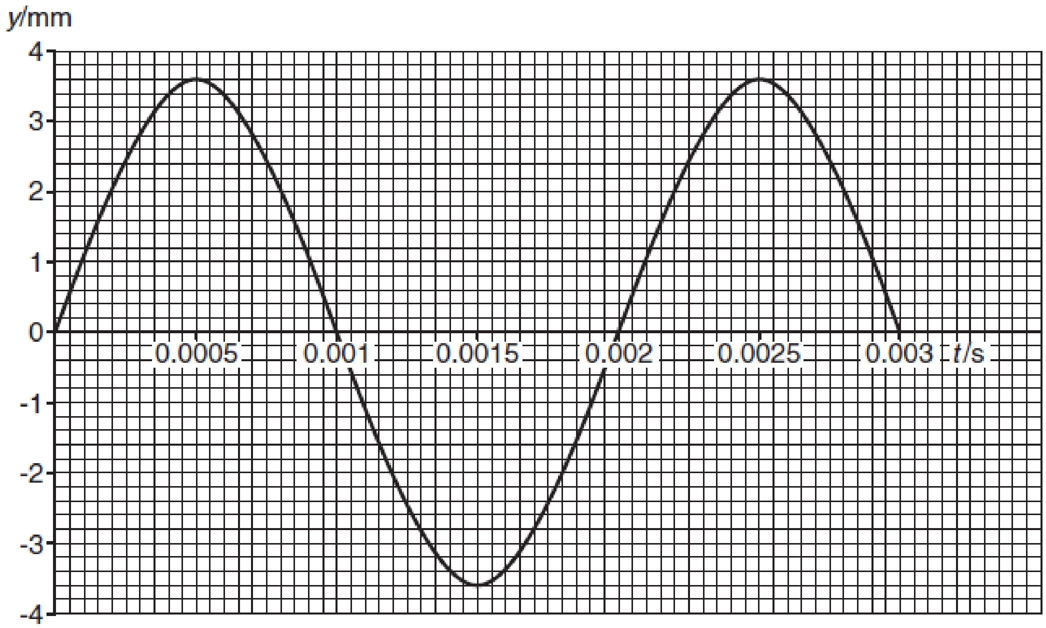


Fig. 4.1

(a) Use Fig. 4.1 to determine, for this wave

(i) the amplitude

amplitude = ... mm **[1]**

(ii) the displacement

1 when $t = 0.40$ ms   displacement = ... mm **[1]**

2 when $t = 1.80$ ms   displacement = ... mm **[1]**

(iii) the period period = ... ms [1]

(iv) the frequency.

frequency = ... Hz [2]

(b) Draw on Fig. 4.1 the displacement-time graph, for the time interval of 0.0030 s, for a wave of half the frequency and half the amplitude of the wave shown in Fig. 4.1. **[2]**

(c) Fig. 4.2 shows, at a given instant, the shape of a stretched rope along which a transverse wave is travelling from left to right. **A**, **B**, **C** and **D** are four particles on the rope.

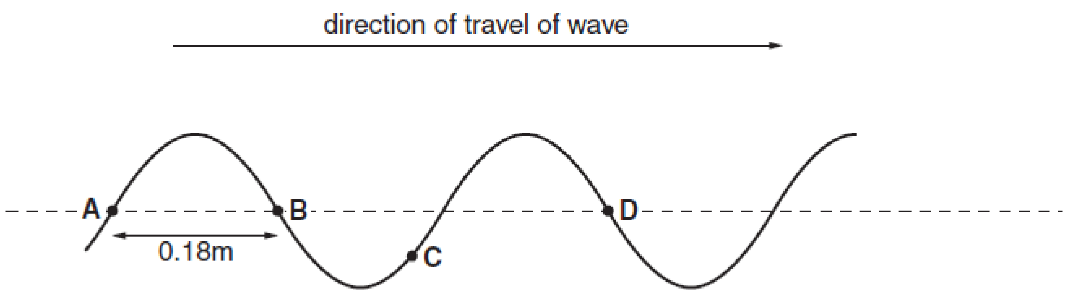


Fig. 4.2

(i) On Fig. 4.2 label the wavelength λ of the wave. **[1]**

(ii) The distance between **A** and **B** is 0.18 m. The frequency of the wave is 5.0 Hz. Calculate the speed of the wave.

speed = ... m s^{-1} **[3]**

(iii) On Fig. 4.2 sketch the shape of the rope a very short time later. **[1]**

(iv) On Fig. 4.2 draw arrows to show the directions in which the particles **B** and **C** are moving during this very short time. **[2]**

(v) State the phase difference between the vibrations of particles **A** and **D**.

phase difference = ... unit .... **[2]**

5.

(a) Explain what is meant by the *principle of superposition*.

....

....

.... **[2]**

(b) In an experiment to produce observable interference fringes, two coherent, monochromatic (one wavelength) light sources, $\mathbf{S_1}$ and $\mathbf{S_2}$, are placed in front of a white screen, as shown in Fig. 5.1.

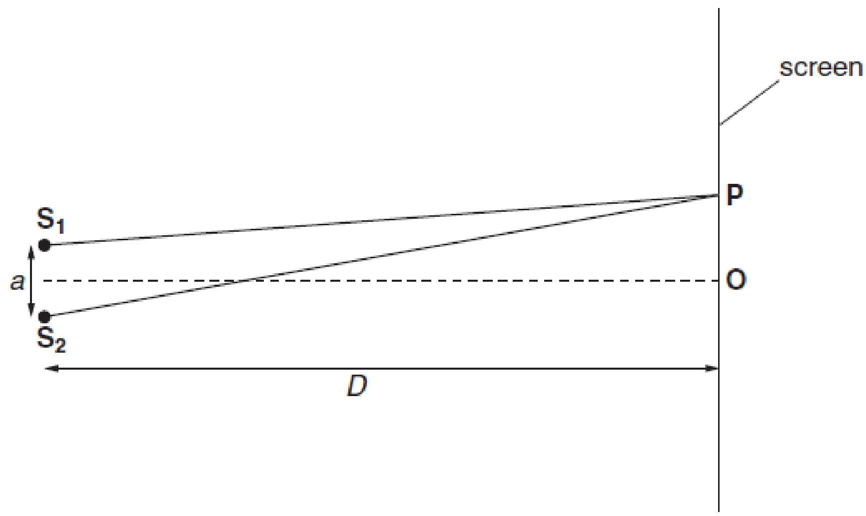


Fig. 5.1

(i) The point **P** is the position of the **first dark** (minimum intensity) fringe closest to the central bright (maximum intensity) fringe at **O**. State, in terms of the wavelength λ, the path difference between $\mathbf{S_1P}$ and $\mathbf{S_2P}$.

path difference = ... **[1]**

(ii) Show on Fig. 5.1 the approximate position of the **first bright** fringe on the screen closest to the central bright fringe at **O**. Label this **B**. **[1]**

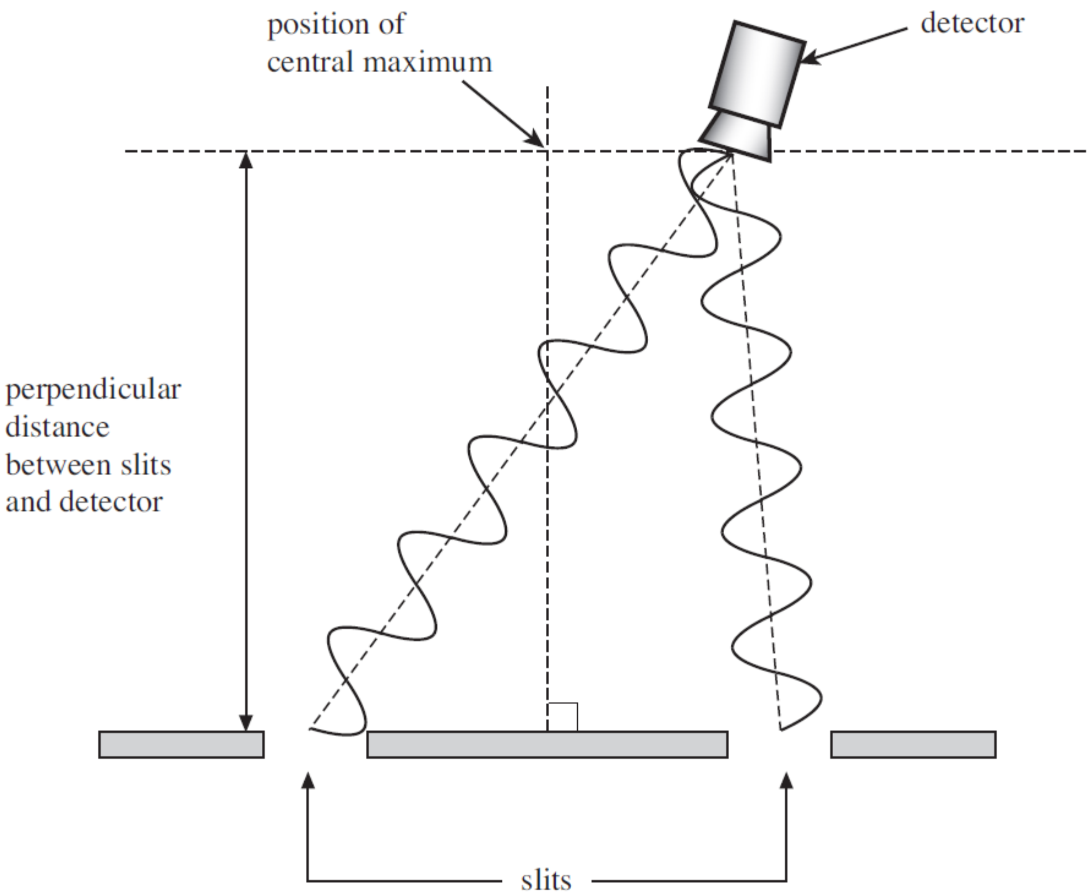
(iii) In a particular experiment, the distance D from the sources to the screen is 1.6 m. The wavelength of the light is 6.4×10^{-7} m and the distance between **O** and **P** is 3.6 mm. Calculate the distance a between the sources $\mathbf{S_1}$ and $\mathbf{S_2}$.

a = ... m **[3]**

6.

Figure 5 shows the paths of microwaves from two narrow slits, acting as coherent sources, through a vacuum to a detector.

Figure 5



(a) Explain what is meant by *coherent sources*.

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....

(2 marks)

(b) (i) The frequency of the microwaves is 9.4 GHz.

Calculate the wavelength of the waves.

wavelength = ... m

(2 marks)

(b) (ii) Using **Figure 5** and your answer to part **(b)(i)**, calculate the path difference between the two waves arriving at the detector.

path difference = ... m

(1 mark)

(c) State and explain whether a maximum or minimum is detected at the position shown in **Figure 5**.

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(3 marks)

(d) The experiment is now rearranged so that the perpendicular distance from the slits to the detector is 0.42 m. The interference fringe spacing changes to 0.11 m.

Calculate the slit separation. Give your answer to an appropriate number of significant figures.

slit separation = ... m

(3 marks)

(e) With the detector at the position of a maximum, the frequency of the microwaves is now doubled. State and explain what would now be detected by the detector in the same position.

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(3 marks)

7.

Fig. 2.1 shows a ray of light entering a semi-circular glass block and reaching the glass/air interface at the mid-point **M** of the straight face.

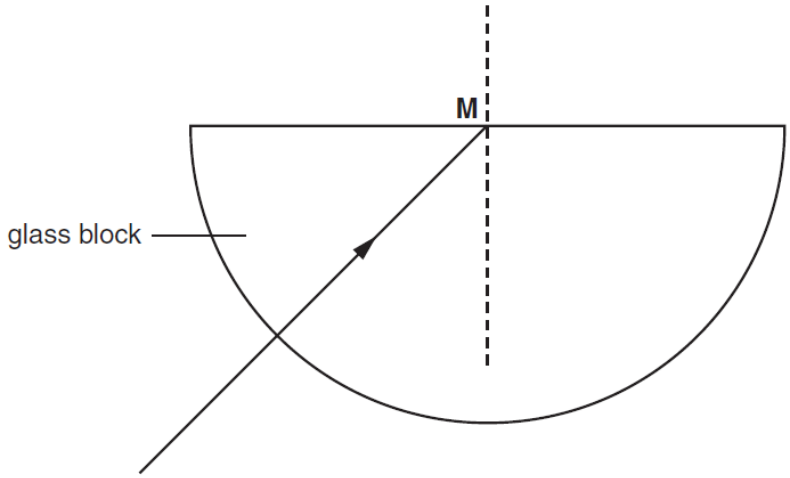


Fig. 2.1

(a) The ray of light meets the glass/air interface with an angle of incidence equal to the critical angle *C*.

(i) Label the angle *C* on Fig. 2.1. [1]

(ii) Show on Fig. 2.1 the path followed by the ray when it leaves the glass/air interface. [1]

(iii) State the angle of incidence for the ray of light as it enters the curved surface of the block.

angle = ...° [1]

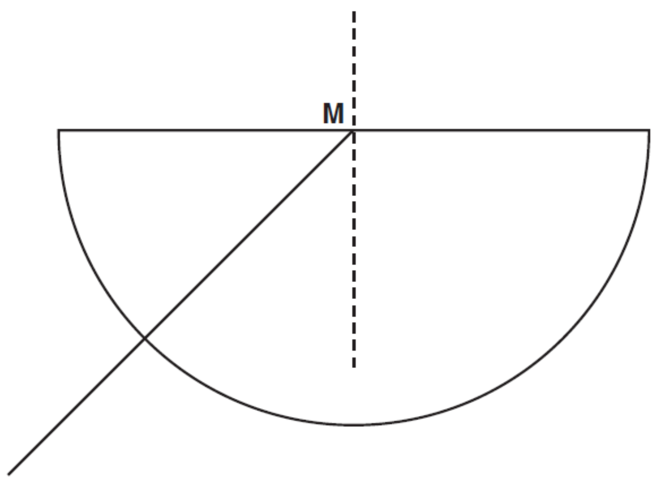


Fig. 2.2

(b) Fig. 2.2 shows the same ray of light as in Fig. 2.1.

On Fig. 2.2 draw two more rays that enter the curved surface and reach the midpoint **M** of the straight face at an angle of incidence

(i) less than *C* – label this ray **1**

(ii) greater than *C* – label this ray **2**.

Show the path followed by ray **1** after reaching the point M – again label this ray **1**.
Show the path followed by ray **2** after reaching the point M – again label this ray **2**. [2]

(c) The refractive index of the glass block is 1.54. Calculate

(i) the value of the critical angle *C*

C = ...° [2]

(ii) the speed of light in the glass

speed of light = ...m s^{-1} [3]

(iii) the angle of refraction corresponding to an angle of incidence, in the glass at **M**, of 30°.

angle of refraction = ...° [3]

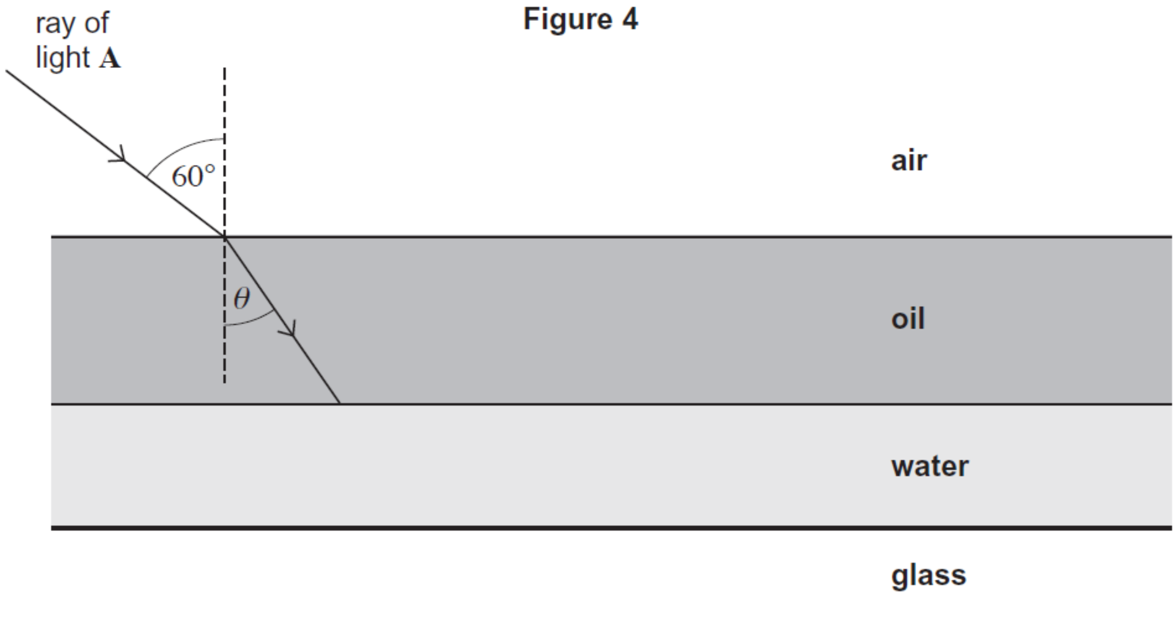
8.

Figure 4 shows a ray of light **A** incident at an angle of 60° to the surface of a layer of oil that is floating on water.

refractive index of oil = 1.47

refractive index of water = 1.33

Figure 4



(a) (i) Calculate the angle of refraction θ in **Figure 4**.

[2 marks]

angle .... degrees

(a) (ii) Calculate the critical angle for a ray of light travelling from oil to water.

[2 marks]

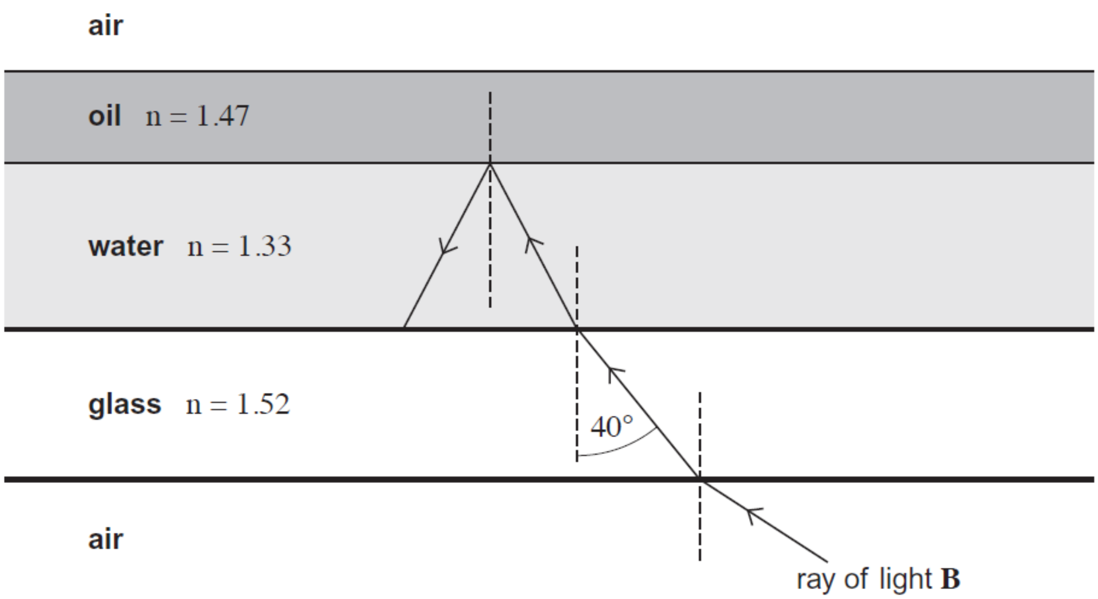
angle .... degrees

(a) (iii) On **Figure 4** continue the path of the ray of light **A** immediately after it strikes the boundary between the oil and the water.

[2 marks]

(b) In **Figure 5** a student has incorrectly drawn a ray of light **B** entering the glass and then entering the water before totally internally reflecting from the water–oil boundary.

Figure 5



The refractive index of the glass is 1.52 and the critical angle for the glass–water boundary is about 60°.

Give **two** reasons why the ray of light **B** would **not** behave in this way. Explain your answers.

[4 marks]

reason 1 ....

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explanation ....

....

....

reason 2 ....

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explanation ....

....

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