Rewarding Learning

Centre Number

71

Candidate Number

ADVANCED SUBSIDIARY
General Certificate of Education
2013

Physics

Assessment Unit AS 2

assessing

Module 2: Waves, Photons and Medical Physics

[AY121]

THURSDAY 20 JUNE, MORNING

MV18

TIME

1 hour 30 minutes, plus your additional time allowance.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.
Answer **all eight** questions.
Write your answers in the spaces provided in this question paper.

INFORMATION FOR CANDIDATES

The total mark for this paper is 75.
Quality of written communication will be assessed in Question **6**.
Figures in brackets printed at the end of each question indicate the marks awarded to each question.
Your attention is drawn to the Data and Formulae Sheet which is inside this question paper.
You may use an electronic calculator.

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(Questions start overleaf)

1 **(a)** Explain what is meant by a transverse wave. [1]

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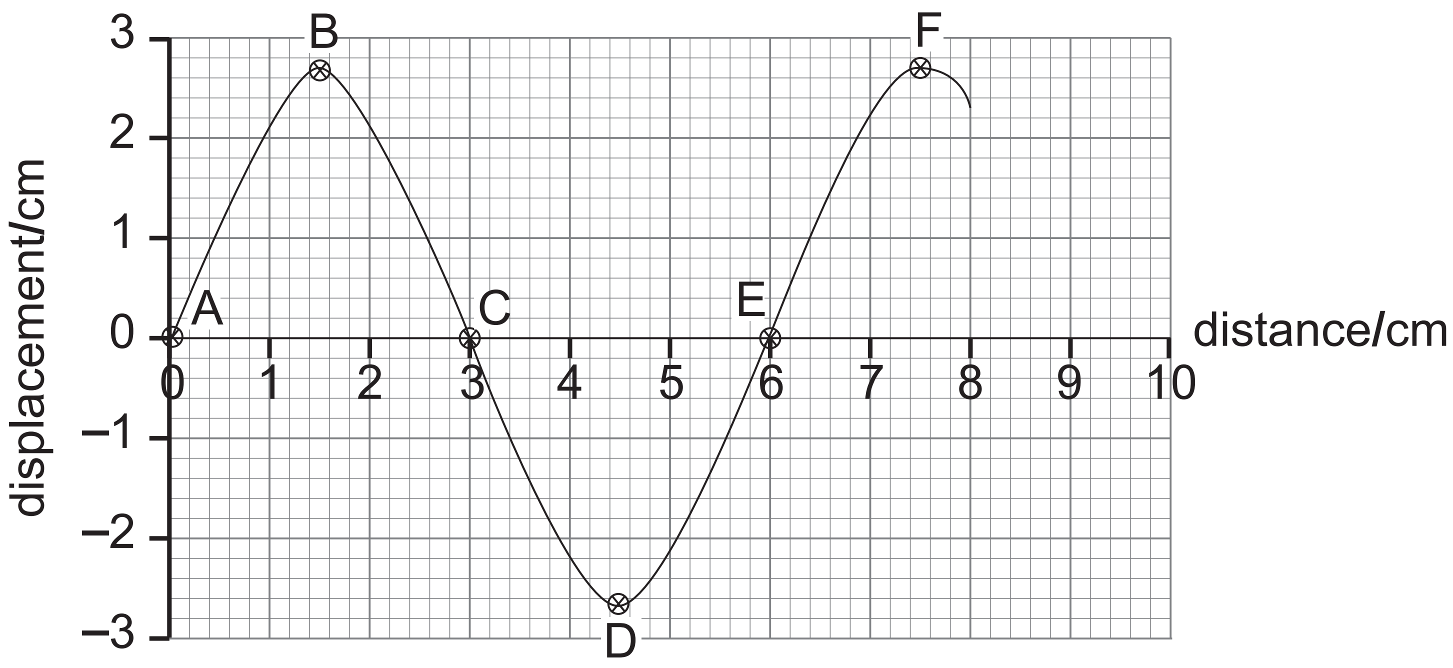
(b) **Fig. 1.1** shows the displacement–distance graph for a progressive transverse wave at time t **=** 0. The frequency of the wave is 0.2 Hz and the wave is travelling from left to right.

Fig. 1.1



(i) What is the wavelength of the wave? [1]

Wavelength **=** ________________ cm

(ii) What is the amplitude of the wave? [1]

Amplitude **=** ________________ cm

(c) (i) In **Fig. 1.1**, which point B, C, D, E or F vibrates 180° out of phase with point A? [1]

Point = ______________

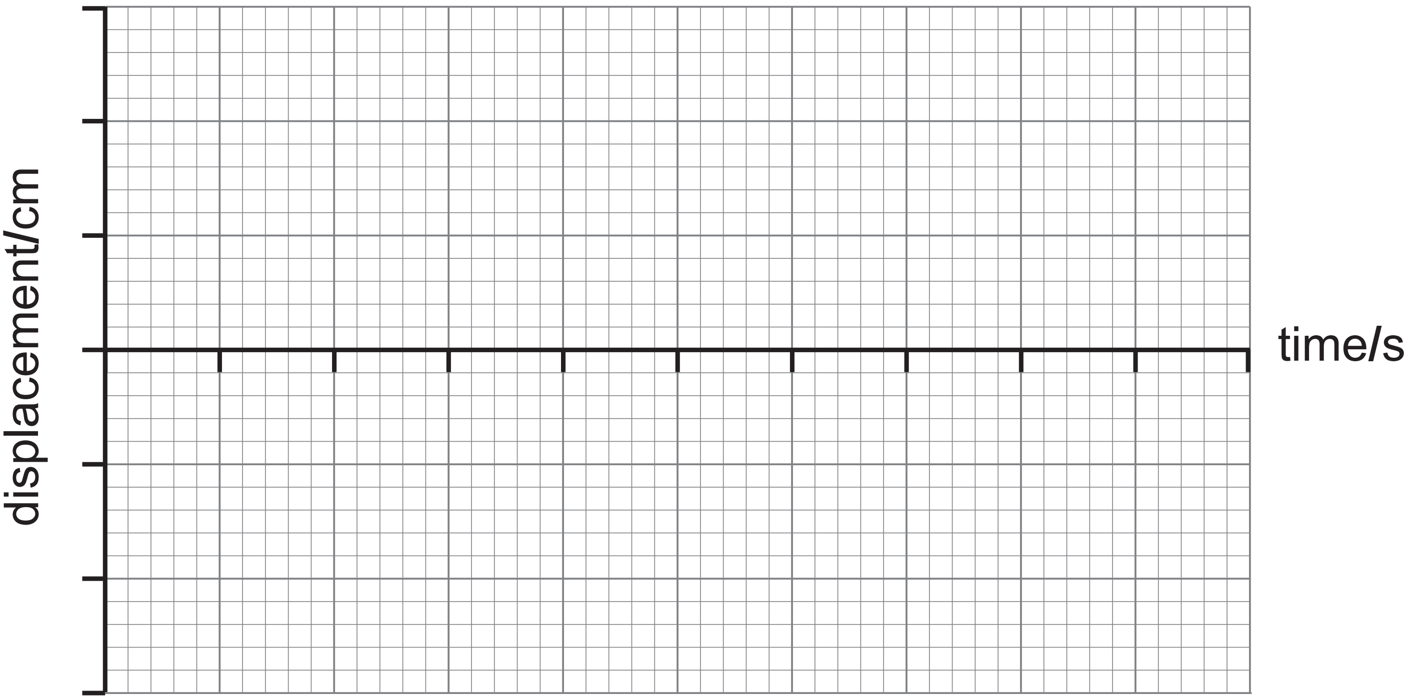
(ii) In **Fig. 1.1**, what is the phase difference between points C and F? [1]

Phase difference = ______________ °

(d) (i) Show that the period of this wave is 5 seconds. [1]

(ii) On the axes of the grid in **Fig. 1.2** draw the displacement–time graph for the particle whose position at t **=** 0 is shown in **Fig. 1.1** at point B. Label both axes with appropriate values and include at least two complete cycles. [2]

Fig. 1.2



(e) Explain why it is not possible to polarise longitudinal waves. [1]

2 (a) Explain what is meant by the **critical angle** at a boundary between glass and air. [1]

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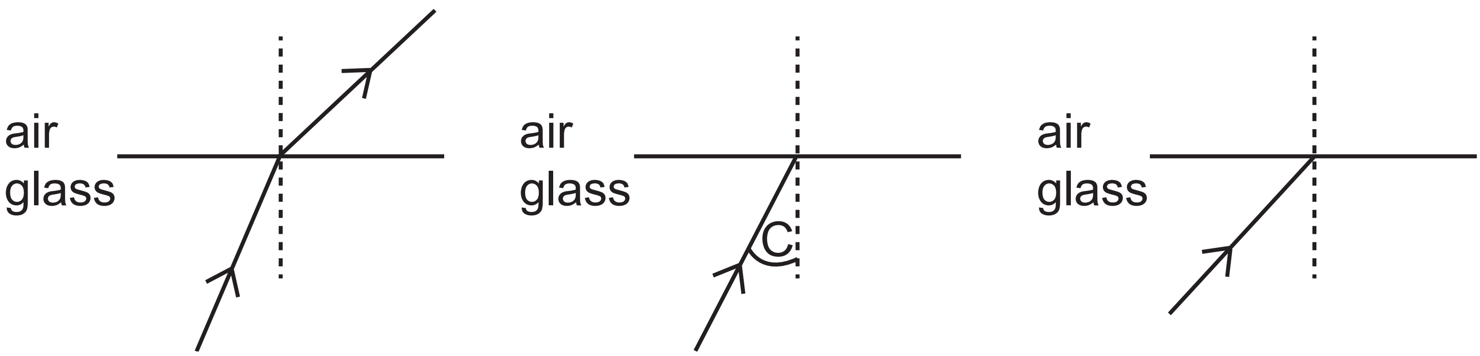
(b) (i) Complete the following diagrams to illustrate the passage of a ray of light out of a glass block when light inside is incident on the plane boundary at different angles. The first one has been completed for you. [2]

Fig. 2.1



light incident at an angle less than the critical angle C
(a)

light incident at an angle equal to the critical angle C
(b)

light incident at an angle greater than the critical angle C
(c)

(ii) What phenomenon is illustrated in **Fig. 2.1 (c)**? [1]

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(iii) Describe how the particular path of the ray in **Fig. 2.1 (b)** can be used to find the refractive index of the glass. [1]

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(c) For a ray of light passing from glass to air with an angle of incidence of 30° at the glass-air boundary, the angle of refraction is 49°.
Calculate the critical angle for the glass. [3]

Critical angle for the glass **=** ______________ °

3 **(a)** A converging lens can be used as a magnifying glass.

(i) Explain what is meant by the principal focus of a converging lens. [1]

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(ii) Describe fully the image formed by a magnifying glass. [1]

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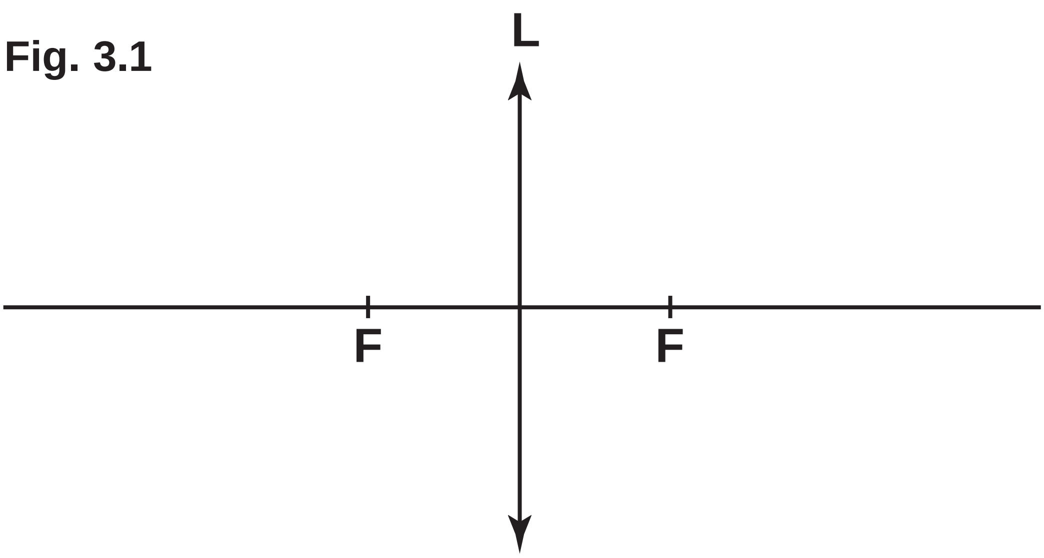
(b) **Fig. 3.1** shows a converging lens **L** with principal foci at the points **F**.
On **Fig. 3.1**, draw a ray diagram to show how the converging lens may be used as a magnifying glass.
Show where the eye should be positioned to view the image. [4]

Fig. 3.1



(c) A magnifying glass of focal length 12 cm is used to form an image which is twice the height of the object. Calculate the object and image distances. [3]

Object distance = ________________ cm

Image distance = ________________ cm

4 In a Young's double slit experiment, a monochromatic light source is placed behind a single slit. Light from the single slit illuminates a double slit arrangement. The light is diffracted at the double slits producing two coherent sources of light. Superposition occurs where the diffracted beams overlap and an interference pattern is observed on a screen.

(a) Explain the meaning of the following terms as used above.

(i) monochromatic [1]

____

diffracted [1]

____

coherent [1]

____

superposition [1]

____

____

(ii) Describe the interference pattern which is produced on the screen. [1]

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(b) A Young's double slit arrangement produces fringes with a separation of 0.6 mm on a wall 75 cm from the two slits which are 0.8 mm apart. Calculate the wavelength and state the colour of the light used.

Wavelength = ______________________ [2]

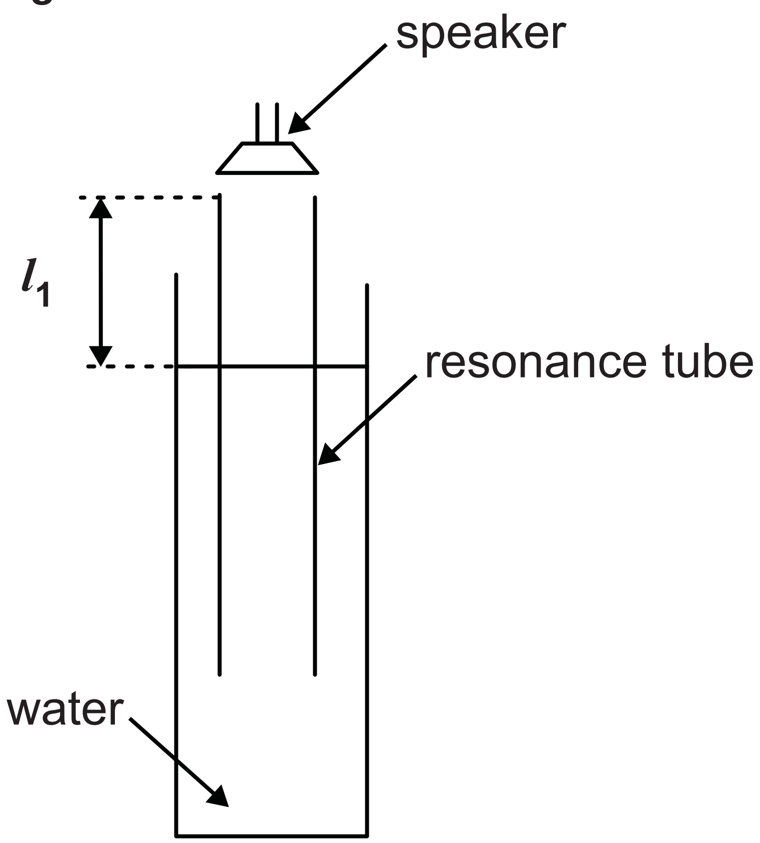
Colour of light = ______________________ [1]

5 A signal generator and speaker are used to produce sound of a specific frequency.

(a) Describe how the frequency of the sound can be determined using a microphone connected to a cathode ray oscilloscope. [3]

(b) The frequency of the sound from the speaker was found to be 295 Hz.
The speaker was held over the end of a resonance tube in an arrangement shown in **Fig. 5.1**.

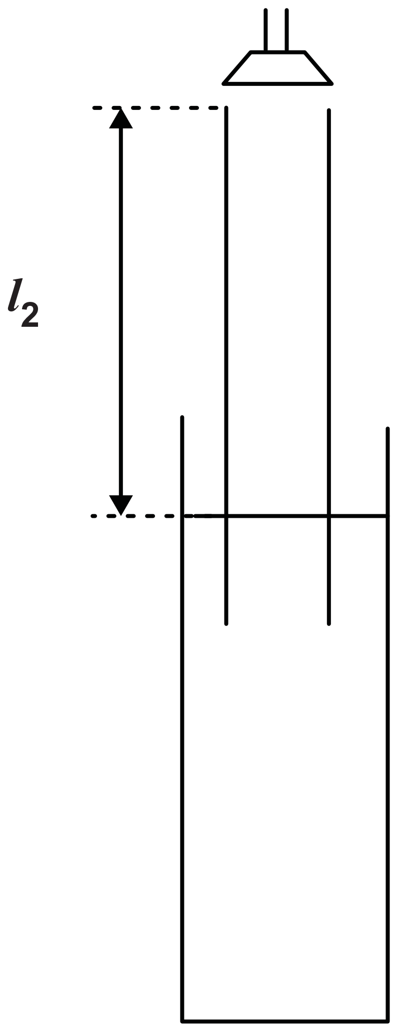
Fig. 5.1



(i) The position of the inner tube is raised from the lowest position until the note is at its loudest at length l_1. This is the first position of resonance.
On **Fig. 5.1** draw the standing wave corresponding to this position. [1]

(ii) The tube is then raised further out of the water until a second resonance position is found at length $\boldsymbol{l_2}$. On **Fig. 5.2** draw the standing wave corresponding to this position. [1]

Fig. 5.2



(iii) The speed of sound in air is 345 $m\,s^{-1}$. Calculate the wavelength of the sound. [1]

Wavelength = ________________ m

(iv) Calculate the first two resonance lengths $\boldsymbol{l_1}$ and $\boldsymbol{l_2}$. [2]

Length $\boldsymbol{l_1}$ = ________________ m

Length $\boldsymbol{l_2}$ = ________________ m

Where appropriate in this question you should answer in continuous prose. You will be assessed on the quality of your written communication.

6 This question is about medical imaging techniques which rely on the use of different types of waves.

(a) Explain the advantage of medical imaging techniques to image the internal organs of the human body. [2]

(b) The flexible endoscope can be used to provide an image of inside a body.

(i) Describe how the area to be viewed inside the body is illuminated. [1]

(ii) Describe fully how the image is transmitted to the observer. [2]

(c) Ultrasound is another method of imaging internal structures of the human body.

(i) Explain the basic principles of how ultrasonic pulses are used to obtain diagnostic information. [2]

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(ii) Describe the basic differences between an A-scan and a B-scan. [2]

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(iii) In preparation for an ultrasound examination, gel is applied before the transducer is placed on the skin. Explain why this is important to ensure the efficiency of the procedure. [1]

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Quality of written communication [2]

(d) Complete **Table 6.1**, by inserting the type of wave used in other medical imaging techniques. [2]

Table 6.1

Imaging Technique	**Wave used**
Endoscopy	Light
Ultrasonic scans	Sound
CT scans	
MRI scans	

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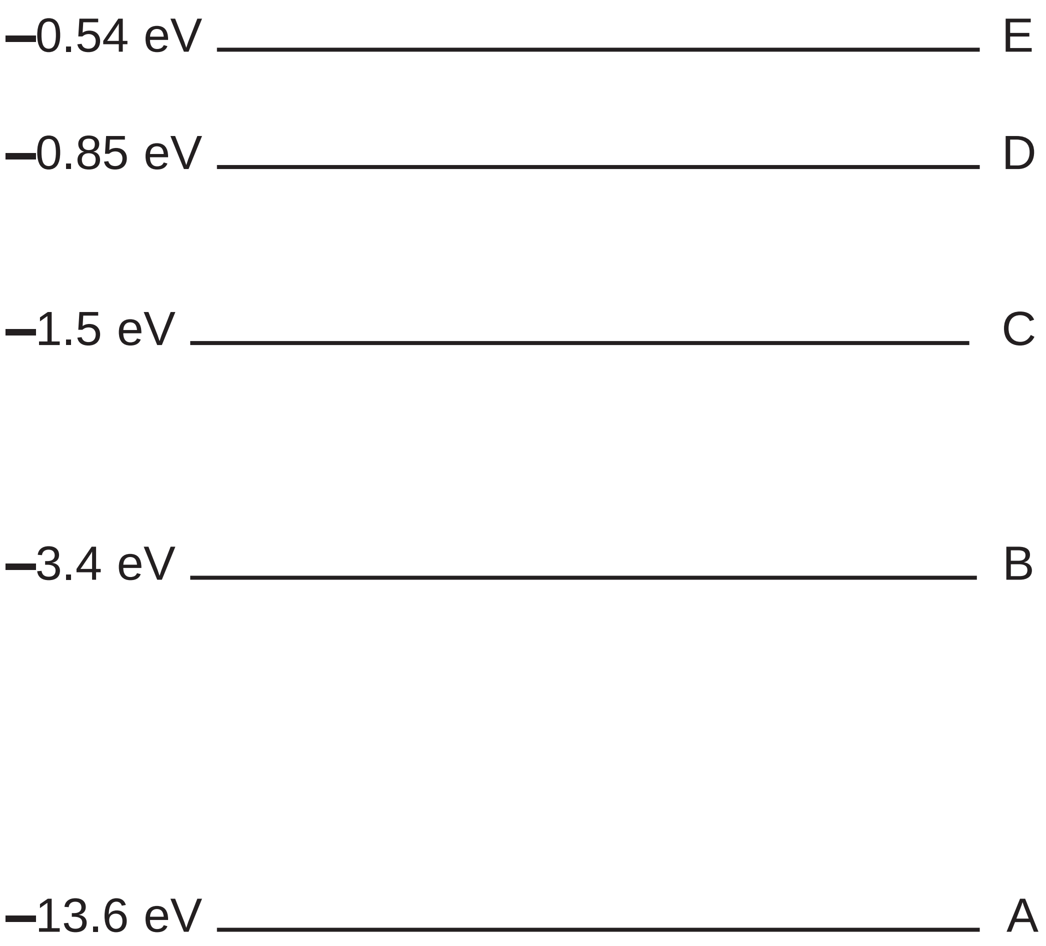
(Questions continue overleaf)

7 **Fig. 7.1** shows **some** of the electron energy levels in the hydrogen atom.

Fig. 7.1



(i) Explain why energy levels are given negative energy values. [2]

(ii) Use the photon model to explain the link between electron energy levels and emission spectra. [2]

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(iii) How many different lines in the emission spectrum are produced by energy changes between the levels shown? [1]

Number of lines = ________________

(iv) When the hydrogen atom is in its ground state the electron is in level A.
What is the least amount of energy this electron needs to escape from the atom? [1]

Minimum energy = ________________ eV

(v) A hydrogen atom is excited so that its electron is raised to level C.
It falls back to the ground state in two stages with the emission of two photons of different wavelengths.
Calculate the wavelength of the photon with the shortest wavelength. [4]

Wavelength = ________________ nm

8 Electromagnetic radiation and moving particles exhibit wave-particle duality.

(a) (i) Give the name of a phenomenon which demonstrates electromagnetic radiation behaving as waves. [1]

____

(ii) Give the name of a phenomenon which demonstrates electromagnetic radiation behaving as particles. [1]

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(iii) Explain the meaning of de Broglie wavelength. [1]

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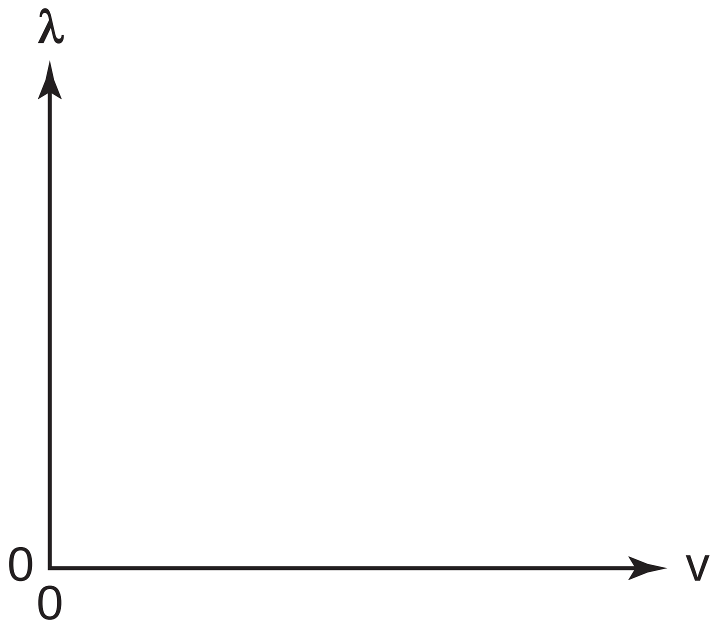
(iv) On **Fig 8.1** sketch a graph to show how the de Broglie wavelength λ of a moving particle depends on its velocity v. [1]

Fig. 8.1



(b) Electron diffraction is evidence of electrons behaving as waves.
Describe the diffraction pattern obtained and state how the pattern will be affected by increasing the energy of the electrons used. [2]

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(c) Electrons can be accelerated through a potential difference.

(i) Calculate the momentum of electrons of wavelength 1.51×10^{-10} m. [1]

Momentum = ______________ $kg\ m\ s^{-1}$

(ii) Calculate the kinetic energy of these electrons. [2]

Kinetic energy = ______________ J

THIS IS THE END OF THE QUESTION PAPER

For Examiner's use only	
Question Number	Marks
1	
2	
3	
4	
5	
6	
7	
8	

Total Marks	

GCE (Advanced Subsidiary) Physics

Data and Formulae Sheet

Values of constants

speed of light in a vacuum	$c = 3.00 \times 10^{8}$ m s^{-1}
elementary charge	$e = 1.60 \times 10^{-19}$ C
the Planck constant	$h = 6.63 \times 10^{-34}$ J s
mass of electron	$m_e = 9.11 \times 10^{-31}$ kg
mass of proton	$m_p = 1.67 \times 10^{-27}$ kg
acceleration of free fall on the Earth's surface	$g = 9.81$ m s^{-2}
electron volt	1 eV $= 1.60 \times 10^{-19}$ J

Useful formulae

The following equations may be useful in answering some of the questions in the examination:

Mechanics

Conservation of energy	$\frac{1}{2}mv^2 - \frac{1}{2}mu^2 = Fs$ for a constant force
Hooke's Law	$F = kx$ (spring constant k)

Sound

Sound intensity level/dB $= 10 \lg_{10} \frac{I}{I_0}$

Waves

Two-source interference $\lambda = \frac{ay}{d}$

Light

Lens formula $\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$

Magnification $m = \frac{v}{u}$

Electricity

Terminal potential difference $V = E - Ir$ (e.m.f. E; Internal Resistance r)

Potential divider $V_{out} = \frac{R_1 V_{in}}{R_1 + R_2}$

Particles and photons

de Broglie equation $\lambda = \frac{h}{p}$