Rewarding Learning

Centre Number	
71	

Candidate Number

ADVANCED SUBSIDIARY
General Certificate of Education
2011

Physics

Assessment Unit AS 2

assessing

Module 2: Waves, Photons and Medical Physics

[AY121]

AY121

MONDAY 27 JUNE, MORNING

TIME

1 hour 30 minutes.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.
Answer **all** 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 **3**.
Figures in brackets printed down the right-hand side of pages 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.

For Examiner's use only	
Question Number	**Marks**
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
Total Marks	

1 The graphs in **Fig. 1.1** and **Fig. 1.2** describe particle oscillation for the same wave.

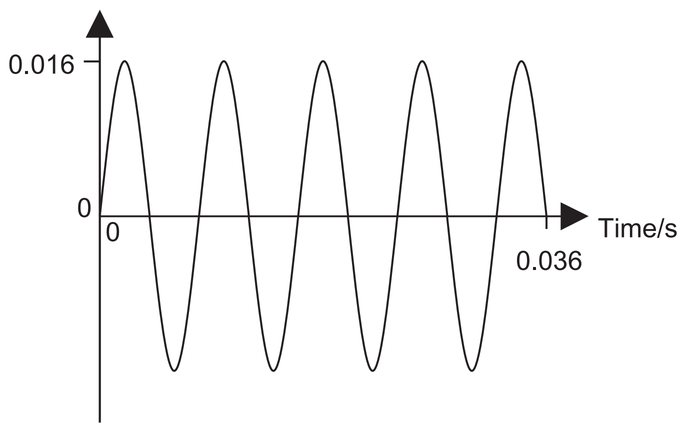

Fig. 1.1

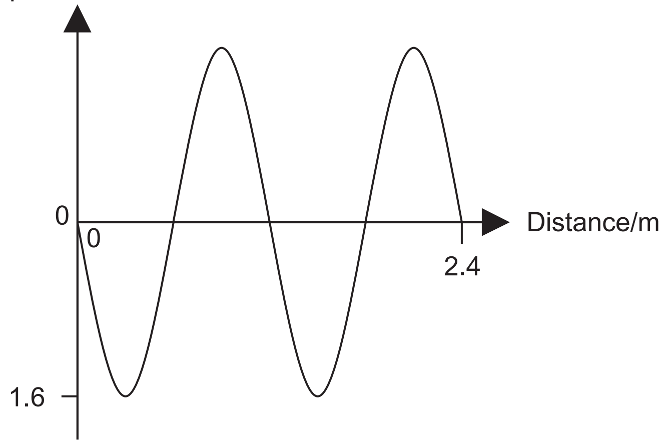

Fig. 1.2

Examiner Only	
Marks	Remark

(a) What evidence exists to support the claim that both graphs describe the same wave?

____

____ [1]

(b) **(i)** Calculate the wavelength of the wave.

Wavelength = ______________ m [2]

(ii) Calculate the frequency of the wave.

Frequency = ______________ Hz [3]

(iii) Calculate the speed of the wave.

Speed = ______________ $m\,s^{-1}$ [2]

Examiner Only	
Marks	Remark

2 Light is incident normally on a **35° – 55° – 90°** triangular glass prism as shown in **Fig. 2.1**. The refractive index for the glass prism is 1.50.

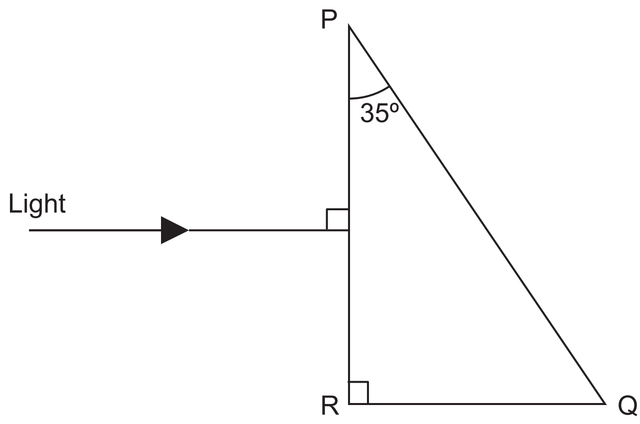

Fig. 2.1

(a) Calculate the critical angle for the glass–air boundary.

Critical angle = _______________ ° [2]

(b) (i) Tick the box (✓) to indicate the side through which the light exits the prism.

PQ		QR		PR	

[1]

(ii) On **Fig. 2.1**, complete the path of the ray as it passes through the prism and on into the air. [1]

(iii) Determine the angle (measured to the normal) with which the light exits the side you indicated in **(b)(i)**.

Angle = _______________ ° [3]

Examiner Only	
Marks	Remark

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

3 **(a)** An object labelled O is placed in front of a diverging lens L as shown in **Fig. 3.1**. Complete the ray diagram to locate the position of the image obtained. Label the image I.

The principal axis of the lens and the ray incident on the optical centre of the lens are included in the diagram. The locations of the principal foci are marked F_1 and F_2.

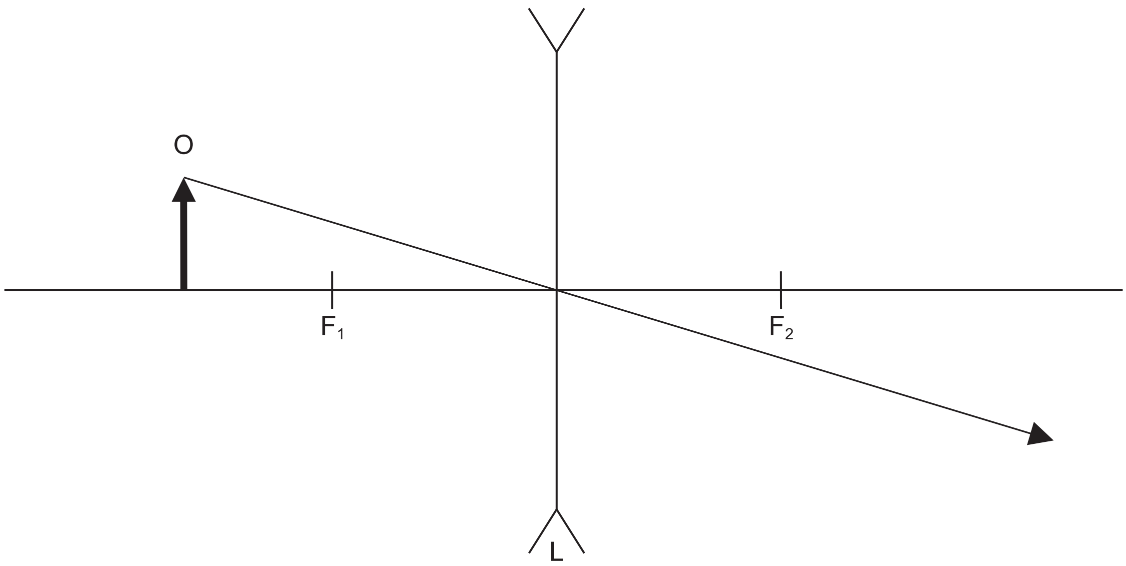

Fig. 3.1

[2]

(b) Describe an experiment to determine the focal length of a converging lens. Your description should include

- a description of the apparatus and how it is used
- the measurement(s) to be taken
- how the results are analysed to obtain an accurate value of the focal length

Use the space below for any diagrams that you may wish to draw in responding to this question.

[4]

Quality of written communication [2]

Examiner Only	
Marks	Remark

4 In a normal six string acoustic guitar the top string is tuned so that its lowest natural frequency is 82 Hz when the full length of the string vibrates. **Fig. 4.1** represents the guitar but only the top string has been shown.

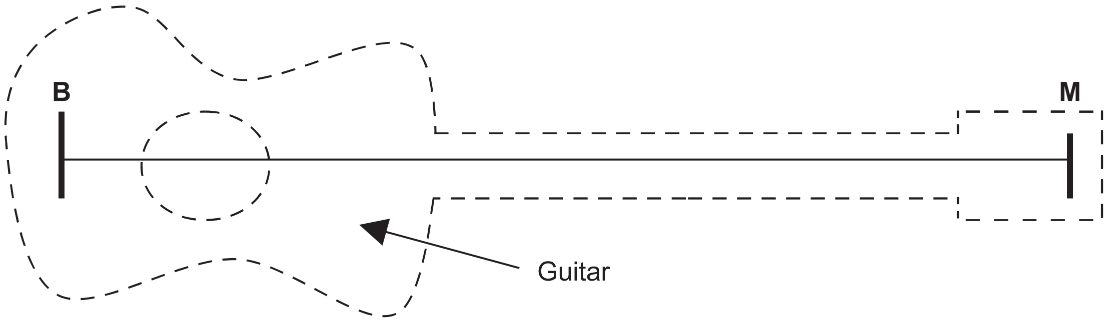

Fig. 4.1

(a) (i) On **Fig. 4.1**, draw the first mode of vibration (the fundamental) for the string. [1]

(ii) Label **every** node N and **every** anti-node A. [2]

(b) (i) If the distance between **B** and **M** is 0.84 m, what is the wavelength of the first mode of vibration of the standing wave on the string?

Wavelength = ______________ m [1]

(ii) To produce a note of a higher frequency the guitarist places one finger at a point X on the string. The string cannot move at that point and the vibrating length is effectively reduced. He then plucks the string with another finger between X and B. The note obtained has a fundamental frequency of 328 Hz. Calculate the distance X to B.

Distance = ______________ m [2]

Examiner Only	
Marks	Remark

(c) Guitarists are able to produce different modes of vibration on the same length of string by lightly touching the string. This creates a node at the point touched but does not reduce the effective length of the string that is vibrating.

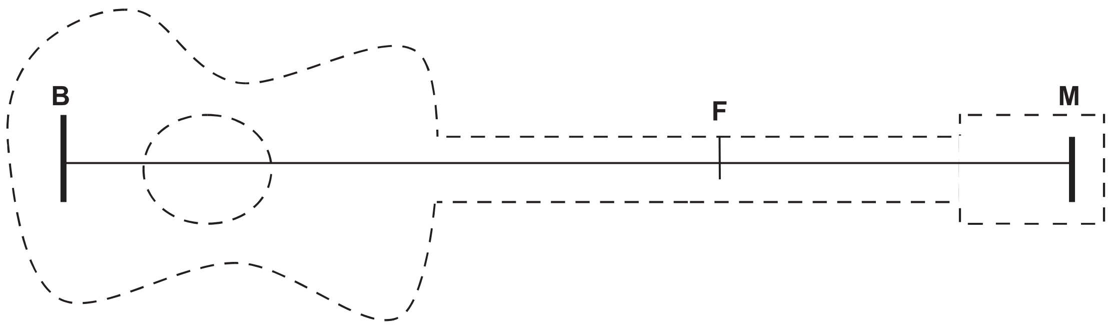

Fig. 4.2

On **Fig. 4.2** sketch the simplest mode of vibration that results when a guitarist touches the string at position F. The distance FM is 0.28 m and the distance BM is 0.84 m. [1]

Examiner Only	
Marks	Remark

5 **Fig. 5.1** illustrates an arrangement to observe interference. Laser light is incident upon an opaque slide on which there are two transparent slits (labelled S and T). The light transmitted through these slits is initially in phase and overlaps in the region between the slits and the screen and the resulting interference pattern is observed on the screen.

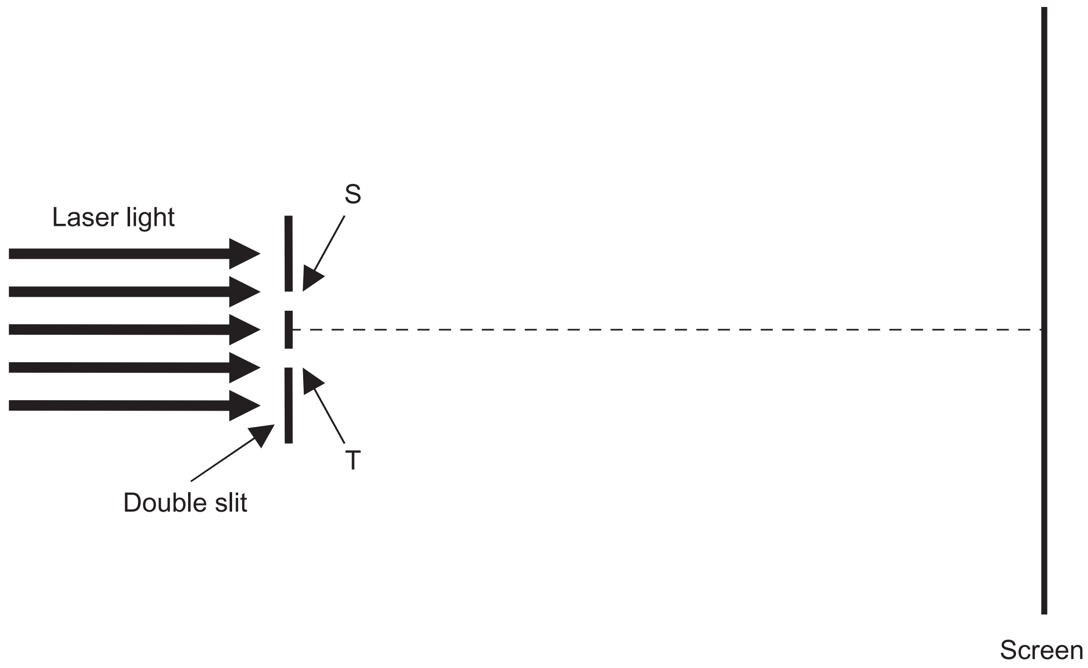

Fig. 5.1

(a) This arrangement ensures that light emerging from slits S and T is coherent. Explain the meaning of the term **coherent** in this context.

____

____ [1]

(b) With this arrangement light emerging from slits S and T is in phase. Explain the meaning of the term **in phase** in this context.

____

____ [1]

Examiner Only	
Marks	Remark

(c) The interference pattern obtained on the screen is a sequence of bright and dark fringes as shown in **Fig. 5.2**.

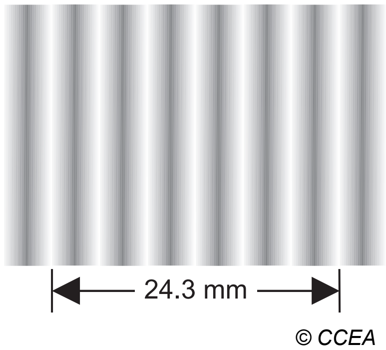

Fig. 5.2

By considering the **paths** followed by the light from slits S and T, explain the formation of a **bright** interference fringe.

____

____

____

____

____ [2]

(d) On the interference pattern obtained, the distance between the centres of seven bright fringes is 24.3 mm (see **Fig. 5.2**). The laser light has a wavelength of 6.42×10^{-7} m and the separation of the double slits S and T is 0.66 mm. Use the data to determine the distance between the double slits and the screen.

Distance = ______________ m [4]

Examiner Only	
Marks	Remark

6 **(a)** A signal generator is connected to a speaker and a cathode ray oscilloscope (CRO). **Fig. 6.1** represents the display on the oscilloscope. The grid on the oscilloscope screen is divided into centimetres.

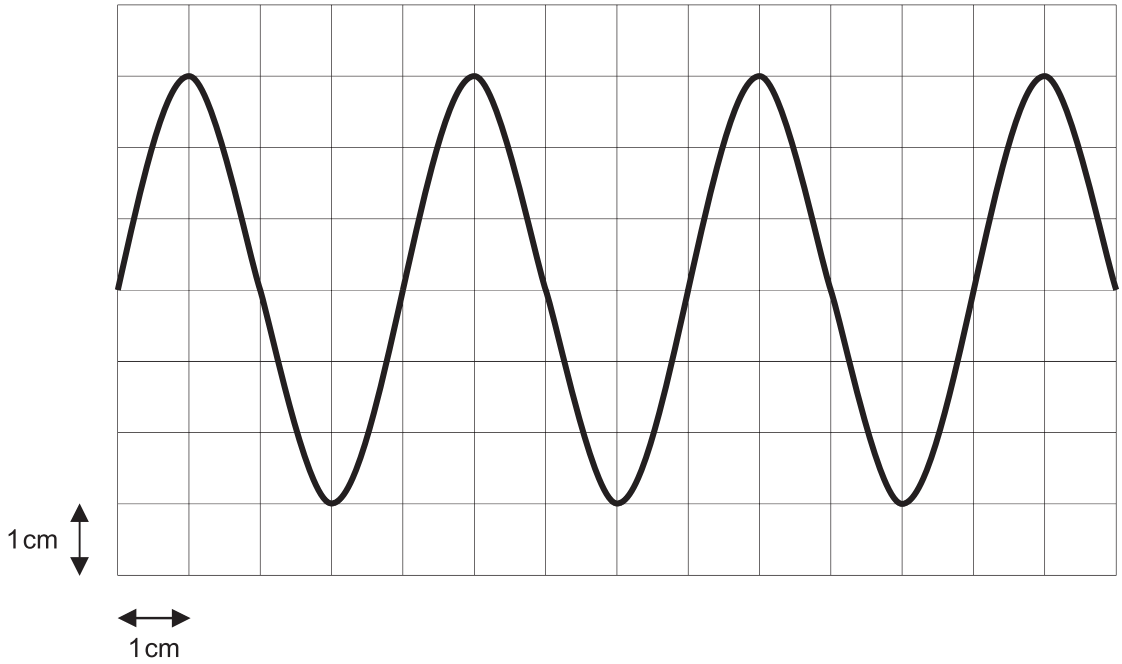

Fig. 6.1

If the time base control on the oscilloscope is set to $\mathbf{40\,\mu s\,cm^{-1}}$, determine the frequency of the sound wave.

Frequency = ______________ Hz [4]

Examiner Only	
Marks	Remark

(b) Residents of a housing development near a busy motorway are shielded from the noise of traffic by a barrier. **Fig. 6.2** is a plan view of the situation showing the houses (A to J), sound wavefronts from the motorway and the barrier.

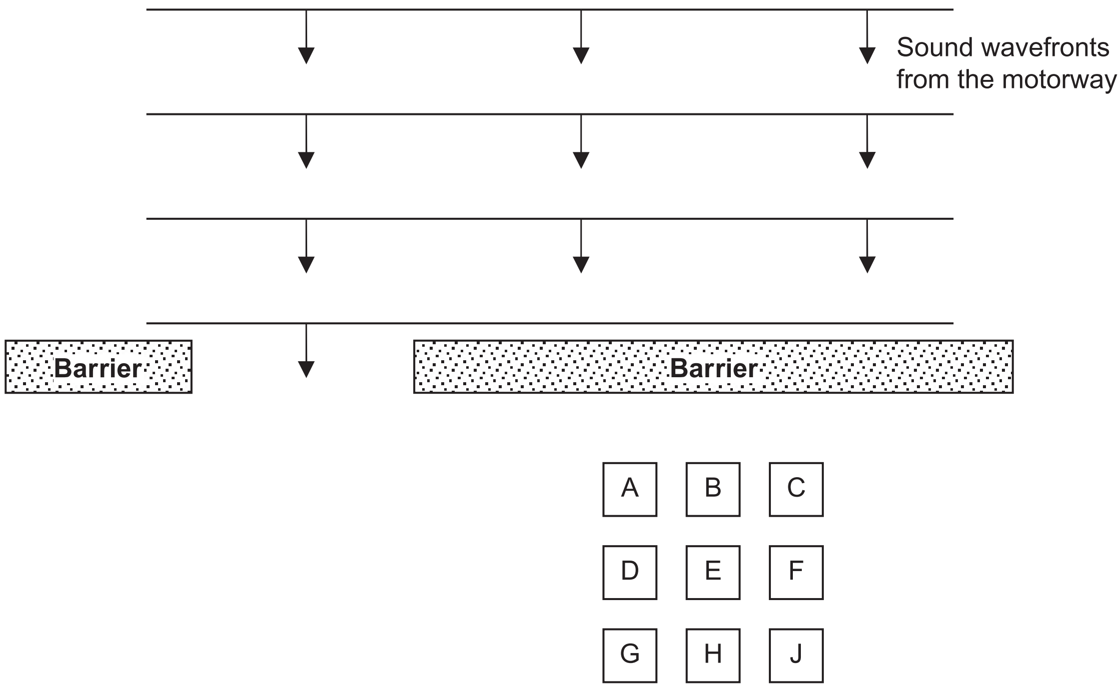

Fig. 6.2

(i) On **Fig. 6.2**, continue the path of the sound wavefront, as it passes the barrier, to show it in its next three positions. [2]

(ii) State and explain what will happen to the shadow zone (the region behind the noise barrier into which no sound enters) when the mean wavelength of the sound from the motorway increases.

____

____

____ [2]

Examiner Only	
Marks	Remark

7 Computed tomography (CT) scanning is a powerful diagnostic tool making use of X-rays.

Examiner Only	
Marks	Remark

(a) What is a "tomograph"?

____

____ [1]

(b) X-rays are produced in two distinct ways. Both ways involve high energy electrons being fired at a tungsten target. Outline the mechanisms by which the high energy incident electrons produce X-rays once they strike the tungsten target.

Mechanism 1 ______________________________________

____

____

Mechanism 2 ______________________________________

____

____ [3]

(c) **Fig. 7.1** shows a simplified diagram of an X-ray tube in which the tungsten target is embedded in a large mass of copper all of which rotates.

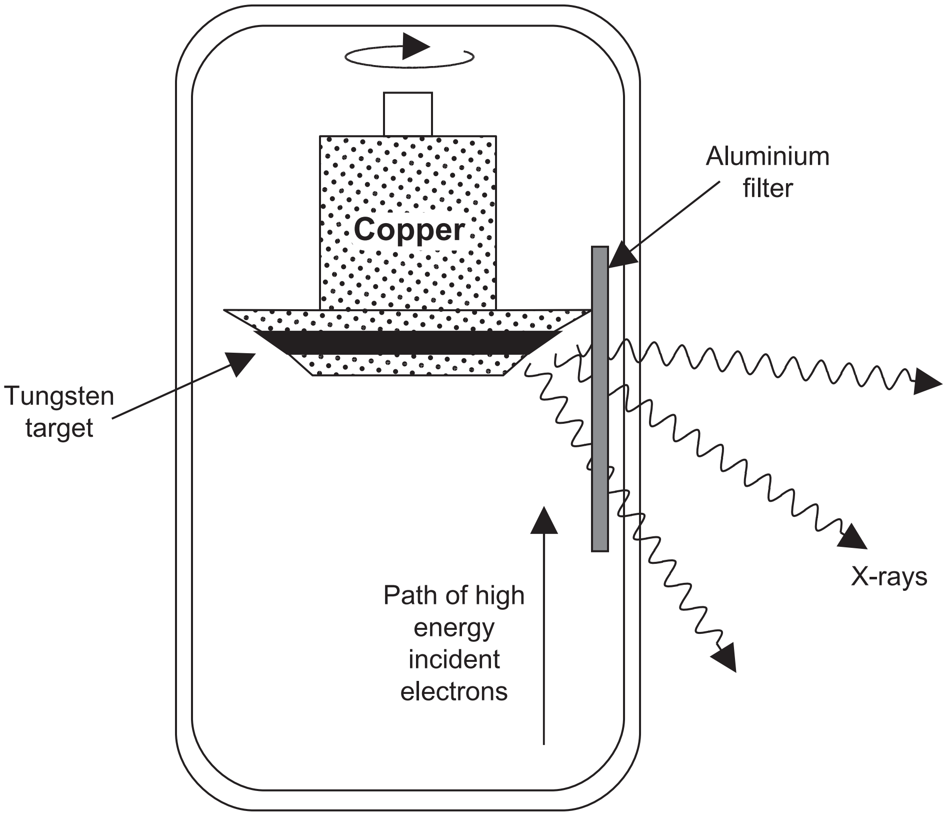

Fig. 7.1

(i) Approximately 1% of the incident energy of the electrons is converted to X-rays. State what happens to the remaining 99% and explain how the tube structure in **Fig. 7.1** has been designed to cope with the 99% energy loss.

____

____

____

____

____ [3]

(ii) The emerging X-rays are passed through a 3 mm thick aluminium filter thereby removing the lower energy X-ray radiation. Explain why this is necessary.

____

____ [1]

Examiner Only	
Marks	Remark

Examiner Only

Marks	Remark

8 **(a)** What is a photon?

____

____ [2]

(b) The graph in **Fig. 8.1** illustrates the relationship between photon energy and radiation frequency.

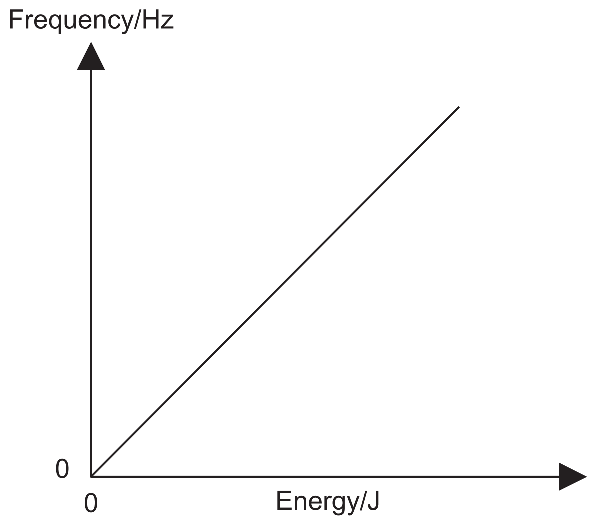

Fig. 8.1

What is the numerical value for the gradient of this graph?

Gradient = ________________ Hz J^{-1} [2]

(c) Calculate the energy of a photon if the radiation has a frequency of 200 MHz and a wavelength of 1.50 m.

Energy = ________________ J [3]

9 **Fig. 9.1** illustrates the electron energy levels, with their values of energy, in a hypothetical atom.

Level	Energy
$n = \infty$	0.0 eV
$n = 4$	– 0.4 eV
$n = 3$	– 6.0 eV
$n = 2$	– 54.4 eV
$n = 1$	– 217.7 eV

Fig. 9.1

For each of the following scenarios, state what will happen, or what must have happened, and explain your answer in terms of the conservation of energy principle.

(a) An electron at $n = 2$ interacts with a quantum of energy equal to 300 eV.

____

____

____ [2]

(b) An electron at $n = 3$ is struck by a photon of energy 5.7 eV.

____

____

____ [2]

(c) A photon of frequency 3.94×10^{16} Hz is emitted.

____

____ [4]

Examiner Only	
Marks	Remark

Examiner Only	
Marks	Remark

10 Some phenomena associated with electromagnetic radiation may be described using a wave model, other phenomena require a particle model for their description. For some phenomena both models are acceptable.

(a) (i) Which of these models may be used to describe:

1. polarisation ____

2. the photoelectric effect _____________________________ [2]

(ii) Name a phenomenon that can be described by either model.

____ [1]

(b) Calculate the de Broglie wavelength of an alpha particle of mass 6.64×10^{-27} kg and charge 3.20×10^{-19} C ejected from a nucleus at $4.50 \times 10^{6}\,\mathrm{m\,s^{-1}}$.

Wavelength = ______________ m [3]

THIS IS THE END OF THE QUESTION PAPER

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