Rewarding Learning

ADVANCED SUBSIDIARY (AS)
General Certificate of Education
2016

Centre Number

Candidate Number

Physics

Assessment Unit AS 2
assessing
Module 2: Waves, Photons and Medical Physics

AY121

[AY121]

TUESDAY 28 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 ten** questions.
You must answer the questions in the spaces provided.
Do not write outside the boxed area on each page or on blank pages.
Complete in blue or black ink only. **Do not write with a gel pen.**

INFORMATION FOR CANDIDATES

The total mark for this paper is 75.
Quality of written communication will be assessed in Question **2**.
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.

1 Electromagnetic waves form a spectrum consisting of seven different frequency regions. A typical frequency for the region of lowest frequency is 10^3 Hz and that for the highest frequency is 10^{22} Hz.

(a) Complete **Table 1.1** by naming these two regions and by stating a typical wavelength for each region.

Table 1.1

Typical frequency/Hz	Region	Typical wavelength/m
10^3		
10^{22}		

[2]

(b) **Fig. 1.1** shows graphs of displacement against time for two waves P and Q. There is a **phase difference** between these two waves.

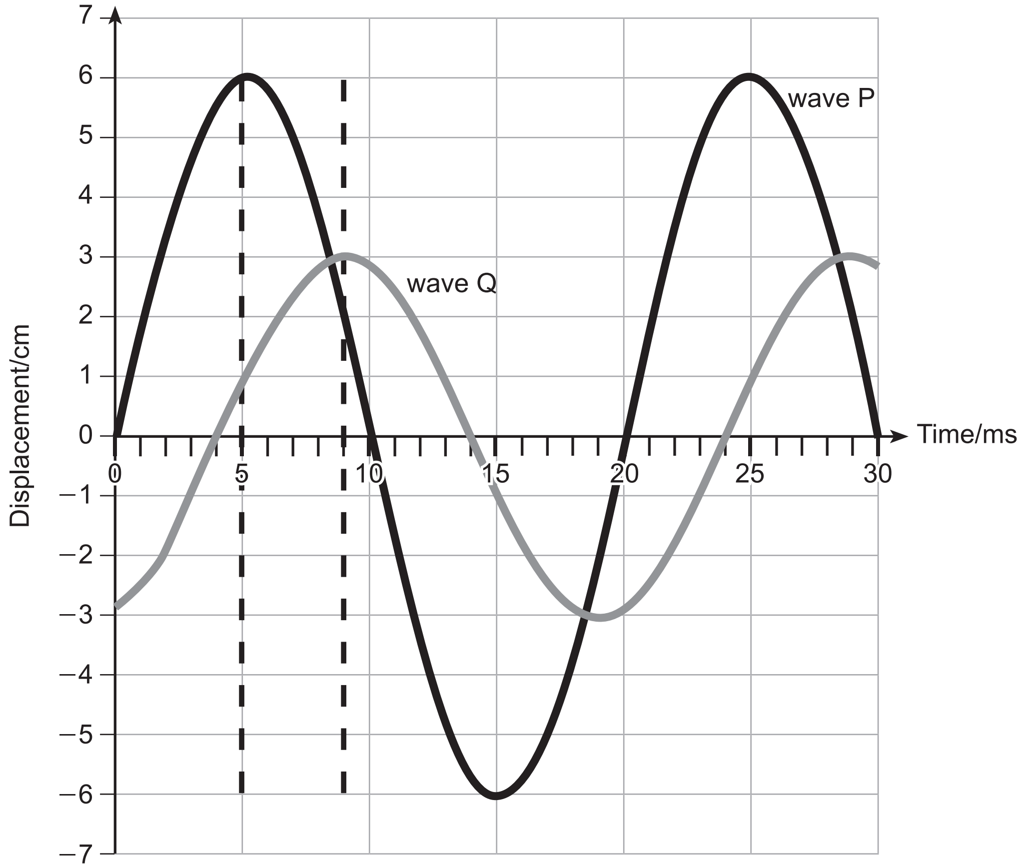

Fig. 1.1

(i) Explain what is meant by **phase difference**.

____

____ [1]

(ii) The dashed vertical lines on **Fig. 1.1** indicate the time that a crest of each wave occurs. Use this information to calculate the phase difference between waves P and Q.

Phase difference = ____________ degrees [3]

[Turn over

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

2 **(a)** Describe an experiment to obtain the **refractive index** of a material.
Include in your description:

- a labelled diagram of the apparatus used
- a description of the procedure
- the measurements taken and how they are used to allow an ***accurate*** value of the refractive index to be calculated.

Diagram

[1]

Procedure

[2]

Measurements

[2]

Quality of written communication [2]

(b) Monochromatic light is incident on a 60° prism made of impure crown glass (refractive index = 1.73). The situation is shown in **Fig. 2.1**. Calculate the angle of incidence ϕ at face AB if total internal reflection is to **just** occur at face AC.

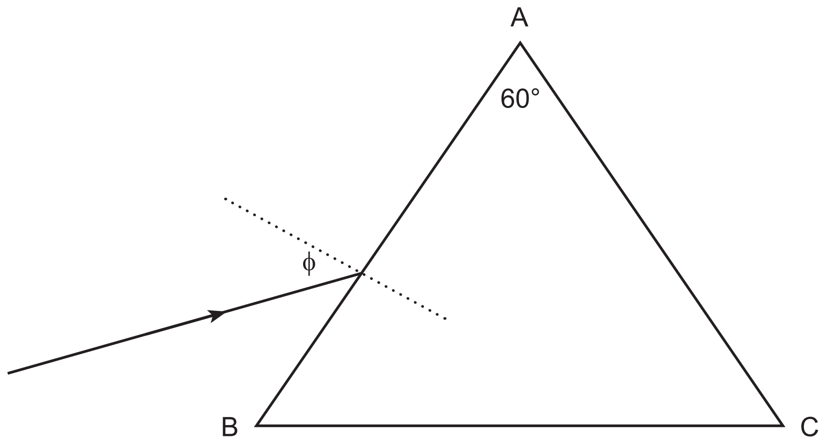

Fig. 2.1

Angle ϕ = ____________________ ° [4]

3 An object **OA** is placed on the principal axis of a lens as shown in **Fig. 3.1**. This lens produces an **upright**, **diminished** image. The positions of the principal foci **F** and optical centre **C** of the lens have been marked.

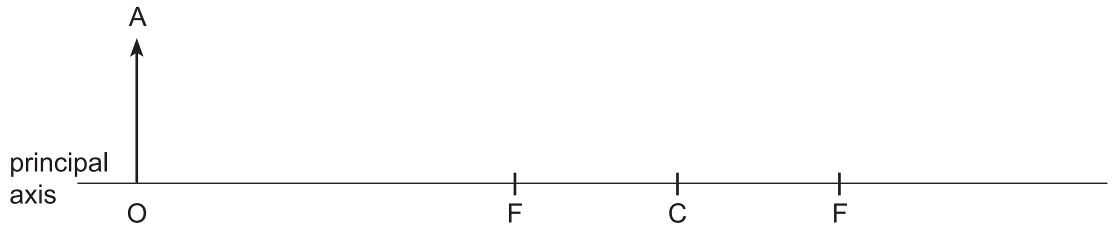

Fig. 3.1

(a) Complete **Fig. 3.1** by:

- drawing and labelling the type of lens used,
- drawing two rays from the top of the object to locate the image,
- labelling the image IB and indicating whether the image is real or virtual. [4]

(b) A student carried out an experiment to determine the focal length of a **converging** lens.

She obtained a series of **u** and **v** values and recorded these in a table with headings as shown in **Table 3.1**.

Table 3.1

u/m	v/m

(i) Draw a **labelled** diagram of the equipment that the student used to obtain this set of results. Clearly identify the measurements **u** and **v** on your diagram.

Diagram

[3]

(ii) The student plots a graph of **(u+v)** against **(uv)** and obtains the graph shown in **Fig. 3.2**.

Explain how she would obtain the focal length of the lens from this graph. (Hint: 1/u + 1/v = 1/f)

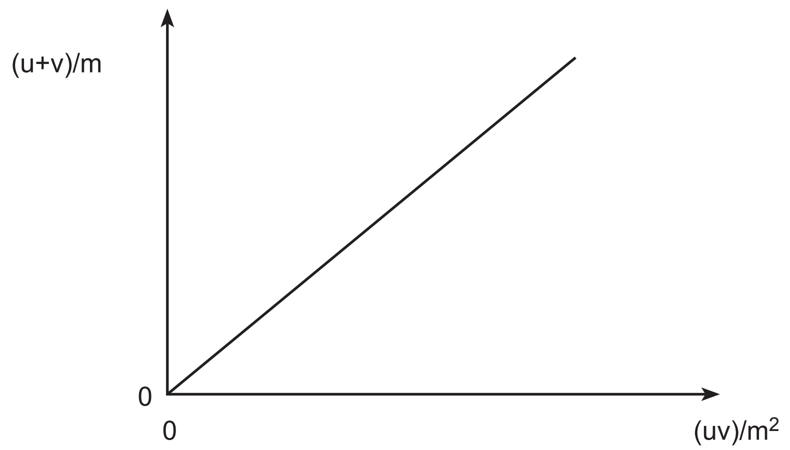

Fig. 3.2

____

____

____

____ [2]

4 **(a)** State the principle of superposition.

____

____

____ [2]

(b) **Fig. 4.1** shows the displacement of two waves, $\mathbf{W_1}$ and $\mathbf{W_2}$ which have different amplitudes and frequencies. Use the principle of superposition to draw the **resultant of these two waves** on **Fig. 4.1**.

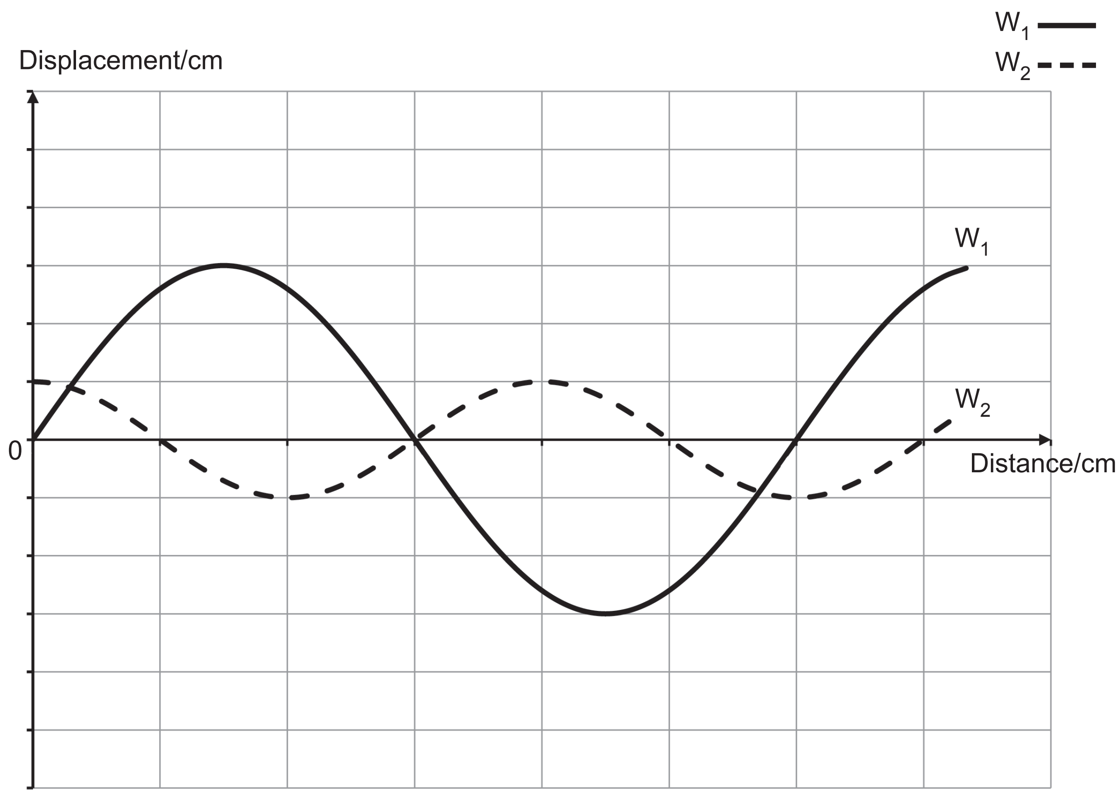

Fig. 4.1

[2]

(c) The following experiment, known as Melde's experiment, can be used to demonstrate standing waves on a string. The apparatus used is shown in **Fig. 4.2**.

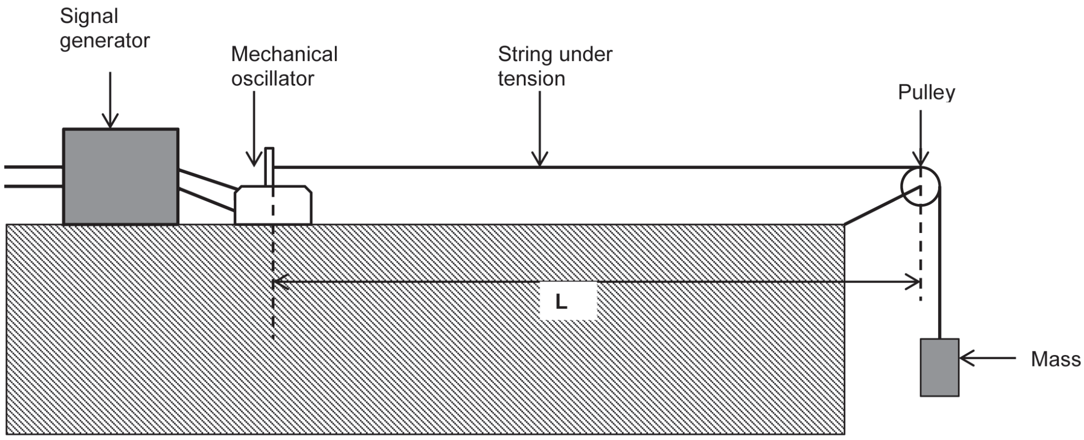

Fig. 4.2

A fixed mass is attached to a string. This mass keeps the string taut. A signal generator is connected to the mechanical oscillator which causes a progressive transverse wave to be sent along the string. This wave is reflected at the pulley end and a standing wave can be observed at certain frequencies.

(i) The frequency of the signal generator is slowly increased from zero. The fundamental mode of vibration is observed when the signal generator is set to 56 Hz. Calculate the length of the string **L** if the speed of the transverse wave in the string is 106.4 m s^{-1}.

Length L = ____________________ m [2]

(ii) The frequency on the signal generator is increased until it reads 168 Hz and another standing wave is obtained. Determine the standing wave pattern obtained and sketch this on **Fig. 4.3**.

The section of string between the mechanical oscillator (M) and the pulley (P) is shown in **Fig. 4.3**.

Fig. 4.3

[2]

(iii) On your sketch, mark the positions of a node N and an antinode A. [1]

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(Questions continue overleaf)

5 A student positions a monochromatic light source **X** in front of a single slit S_1 and a double slit S_2S_3, as shown in **Fig. 5.1**, in order to produce **coherent** sources. An interference pattern of bright and dark fringes is observed on the screen.

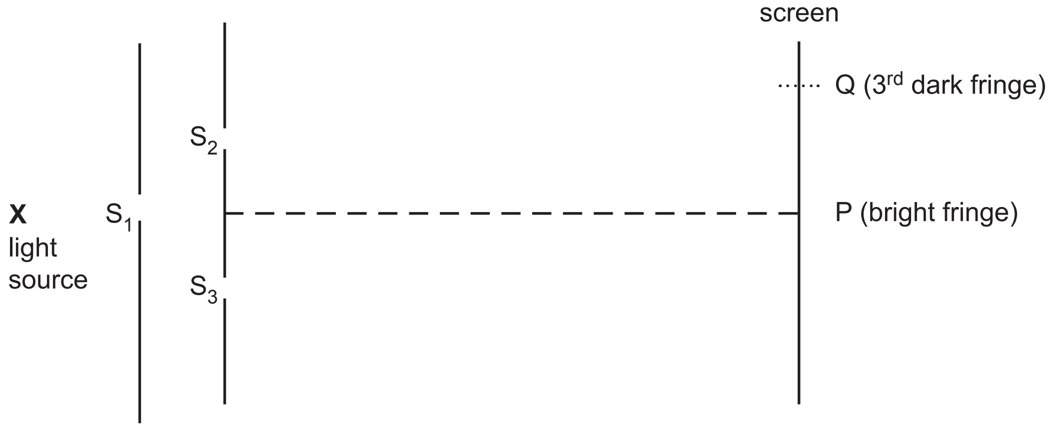

Fig. 5.1

(a) **(i)** What is meant by **coherent** sources?

____

____ [1]

(ii) State 2 additional conditions that must exist for an **observable** interference pattern.

1. ____

2. ____ [2]

(b) **(i)** A dark fringe indicates that **destructive interference** has occurred. In terms of **path difference** state the condition that must be met for complete destructive interference.

____

____ [1]

(ii) The centre of a bright fringe is formed at position P, located along the centre line, midway between S_2 and S_3 as shown in **Fig. 5.1**. The third dark fringe from P occurs at position Q, when the path difference between light coming from S_2 and S_3 is 1.38×10^{-6} m.

Calculate the wavelength of the light source.

Wavelength = ____________________ m [3]

6 A music enthusiast attends a music concert but arrives too late to gain admission to the auditorium for the beginning of the concert. He is asked to wait in a room outside and is disappointed to find that he is seated to the left of an open doorway. He can hear the concert but can't see the orchestra playing on the stage. This is shown schematically in **Fig. 6.1**.

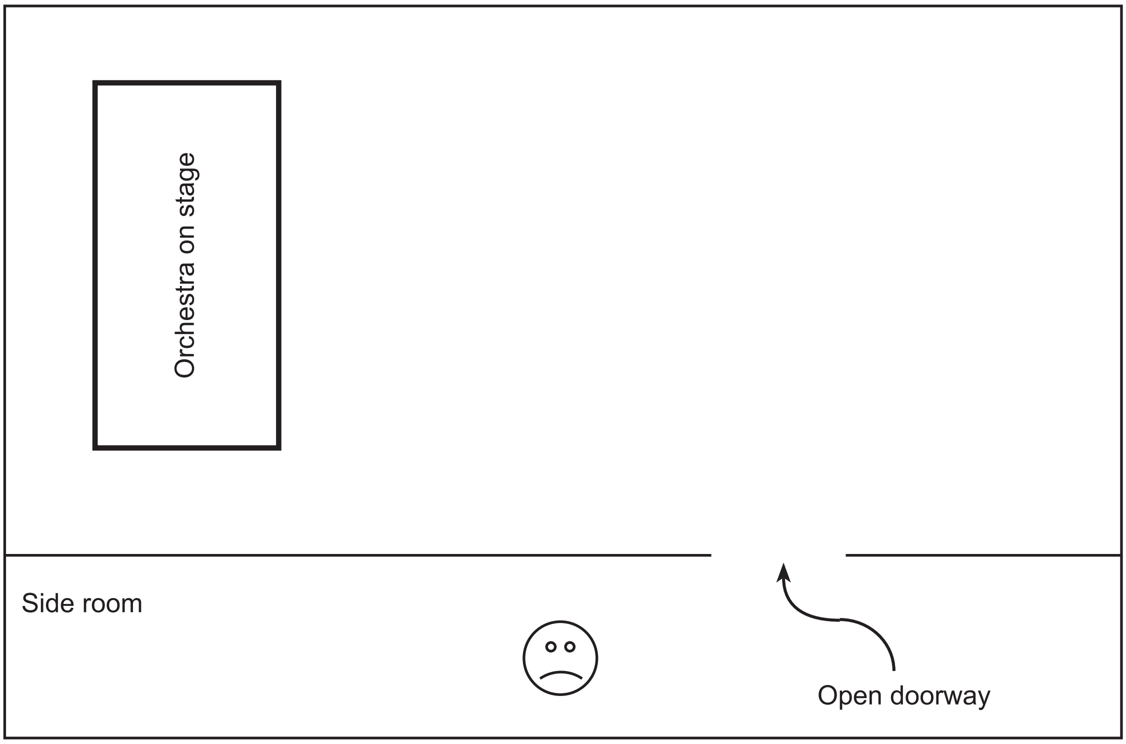

Fig. 6.1

(a) Explain in terms of **diffraction** why he can still hear the music despite not being able to see the orchestra playing it.

____

____

____

____

____

____ [3]

(b) A signal generator is linked to both a speaker and a cathode ray oscilloscope. The sound emitted from the speaker has a frequency of 5 kHz and the trace on the cathode ray oscilloscope is shown in **Fig. 6.2**. The grid on the screen is divided into centimetres.

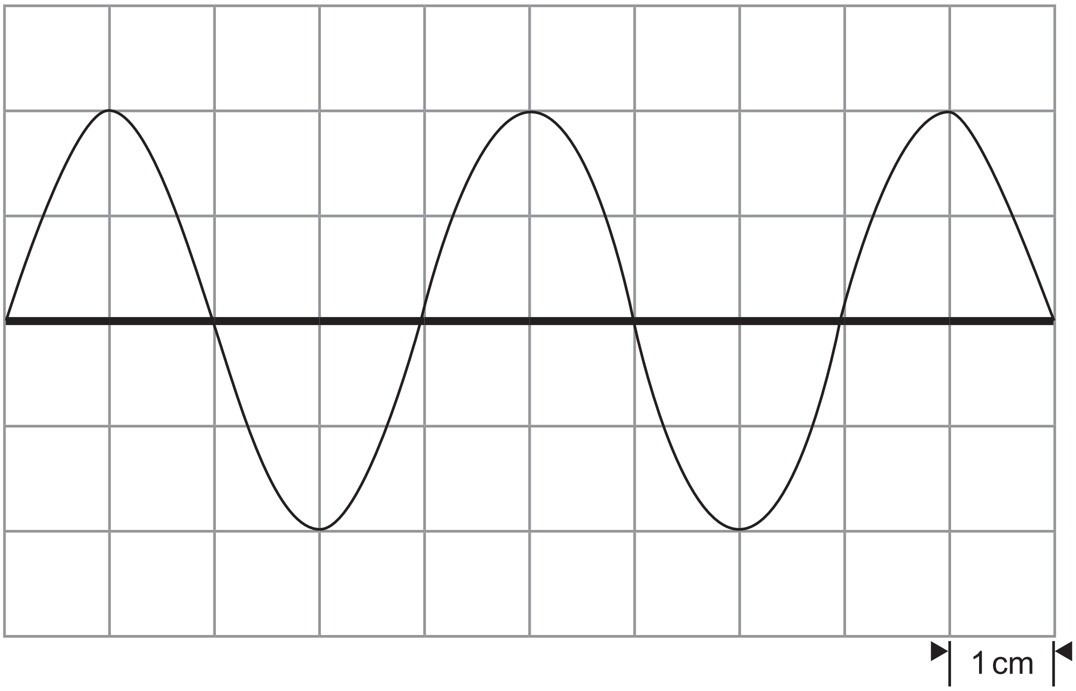

Fig. 6.2

Tick the correct box corresponding to the time base setting on the cathode ray oscilloscope.

Show your working clearly.

Time Base Setting	
5.0 μs cm^{-1}	
8.0 ms cm^{-1}	
0.20 μs cm^{-1}	
50 μs cm^{-1}	
20 ms cm^{-1}	

[3]

[Turn over

7 X-rays are commonly used as an imaging technique in medicine. X-rays are produced by bombarding a metal target with electrons of suitable energy. There are two distinct methods of production.

(a) Describe the **two** methods of X-ray production.

[3]

(b) CT scanning is a powerful diagnostic tool that uses X-rays.

(i) What does CT stand for?

____ [1]

(ii) Both the CT scanner and the conventional X-ray machine require the use of an X-ray beam and a detector. Outline the difference in the procedure employed with the beam and detector when each technique is used.

____

____

____

____ [2]

(iii) State one disadvantage of using a CT scanner instead of a conventional X-ray machine when used for producing images of patients.

____

____ [1]

8 **Photoelectric emission** can occur when metal surfaces are illuminated by electromagnetic radiation. Under certain conditions photoelectrons are emitted from the metallic surface.

(a) State the **conditions** under which photoelectric emission occurs.

____

____

____

____ [2]

(b) The minimum frequency of radiation for which photoelectric emission occurs when a platinum surface is illuminated is 2.5×10^{15} Hz.
Calculate the work function of the platinum surface in eV.

Work function = ________________ eV [3]

(c) The frequency of the illuminating radiation is kept constant at 2.5×10^{15} Hz but the intensity of the radiation is increased.

(i) Explain the effect this would have on the kinetic energy of the emitted photoelectrons.

____

____ [1]

(ii) Explain the effect this would have on the number of photoelectrons emitted in 1 second.

____

____ [1]

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9 The acronym **LASER** stands for **L**ight **A**mplification by the **S**timulated **E**mission of **R**adiation.

(a) Light amplification will only occur for a particular electron arrangement of the atoms within the laser.

(i) Name and describe this arrangement of electrons.

____

____

____ [2]

(ii) An electron may fall between two energy levels due to either spontaneous or stimulated emission. What causes stimulated emission to occur?

____

____

____ [1]

(b) Helium neon lasers were initially developed at Bell telephone laboratories in 1962. They operate at wavelengths of 632.8 nm in the red part of the visible spectrum and are widely used to read the optical disc in Compact Disc, DVD and Blu-ray Disc devices. **Fig. 9.1** shows a simplified diagram of some of the electron energy levels for helium and neon atoms within the laser.

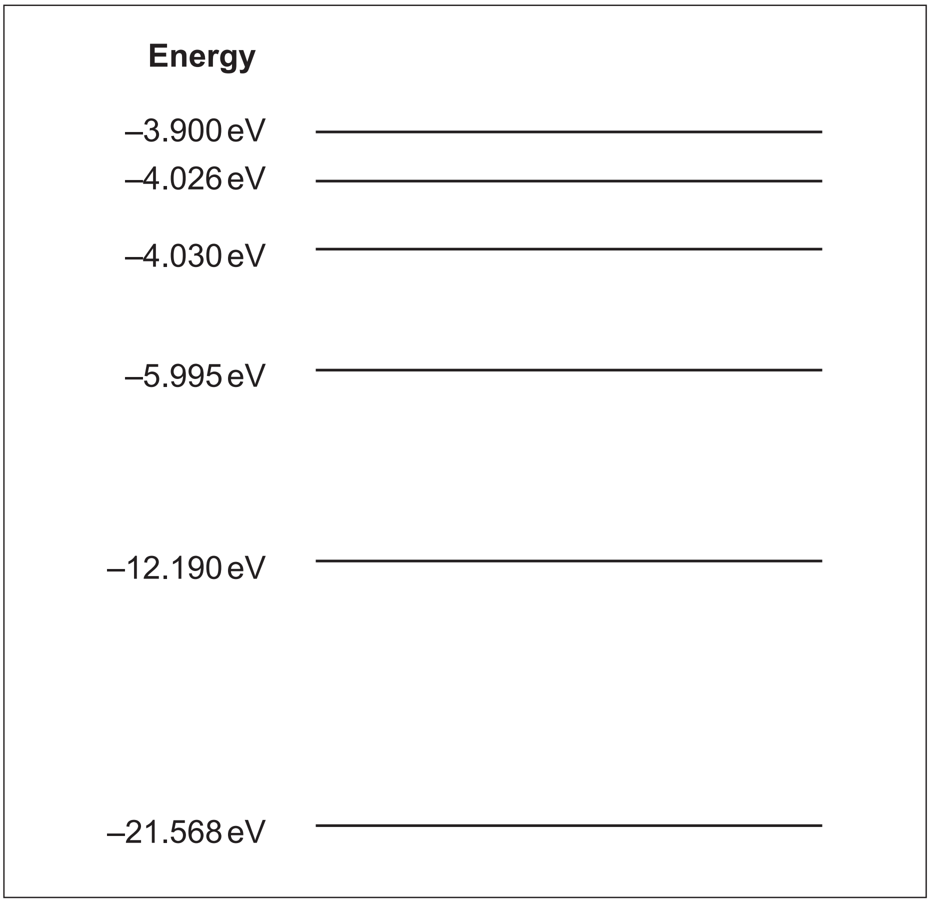


Fig. 9.1

(i) Explain why the energy levels have negative values.

____

____

____ [2]

(ii) Identify the energy levels between which an electron transition would result in the emission of red light with a wavelength of 632.8 nm and associated photon energy of 1.965 eV as in the helium neon laser.

Transition between ____________ eV and ____________ eV [1]

(iii) Draw an arrow between these levels on **Fig. 9.1** to represent this transition. [1]

10 Electron diffraction shows that particles can behave as waves. This can be demonstrated experimentally using the equipment shown in **Fig. 10.1**. The electrons are accelerated from rest in a vacuum by a high voltage supply and passed through a graphite crystal. A diffraction pattern consisting of a central bright spot surrounded by dark and bright concentric rings is observed on a fluorescent screen as shown in **Fig. 10.2**.

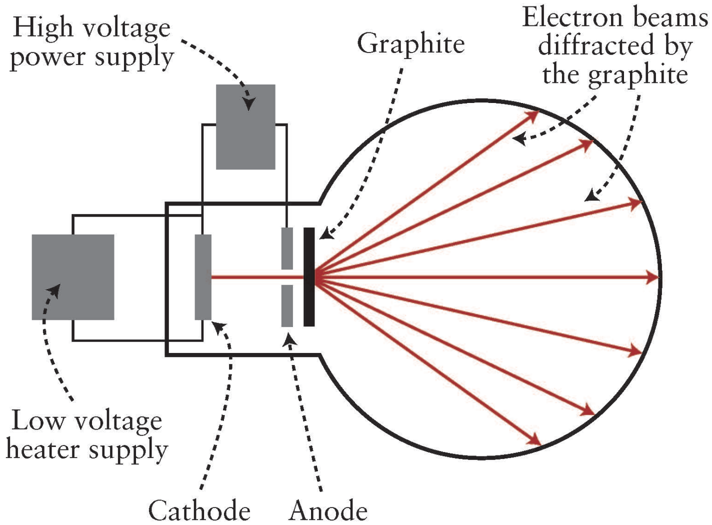
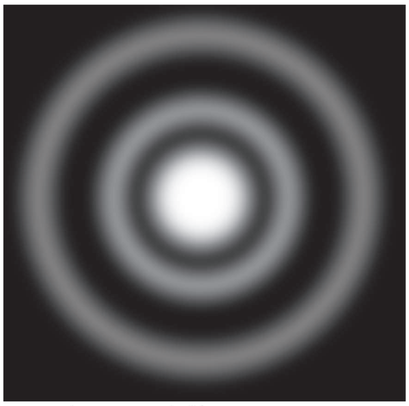


Fig. 10.1



Electron diffraction rings seen on the fluorescent screen

Fig. 10.2

(a) The accelerating potential is 425 V. Calculate the de Broglie wavelength of the electrons when they reach their final speed of 1.22×10^7 m s^{-1}.

Wavelength = ____________________ nm [3]

(b) Describe and explain the effect on the diffraction pattern if the accelerating potential is increased to 495 V.

[3]

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For Examiner's use only		
Question Number	Marks	Remark
1		
2		
3		
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Total Marks		

Examiner Number