RECOGNISING ACHIEVEMENT

ADVANCED SUBSIDIARY GCE **2861**

PHYSICS B (ADVANCING PHYSICS)

Understanding Processes

FRIDAY 11 JANUARY 2008 Afternoon

Time: 1 hour 30 minutes

Candidates answer on the question paper.
Additional materials: Data, Formulae and Relationships Booklet
Electronic calculator
Ruler

CUP/T28411

Candidate Forename		Candidate Surname	

Centre Number						Candidate Number				

INSTRUCTIONS TO CANDIDATES

- Write your name in capital letters, your Centre Number and Candidate Number in the boxes above.
- Use blue or black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully and make sure that you know what you have to do before starting your answer.
- Answer **all** the questions.
- Do **not** write in the bar codes.
- Do **not** write outside the box bordering each page.
- Write your answer to each question in the space provided.

INFORMATION FOR CANDIDATES

- The number of marks for each question is given in brackets [ ] at the end of each question or part question.
- The total number of marks for this paper is 90.
- You are advised to spend about 20 minutes on Section A, 40 minutes on Section B and 30 minutes on Section C.
- There are four marks for the quality of written communication in Section C.
- The values of standard physical constants are given in the Data, Formulae and Relationships Booklet. Any additional data required are given in the appropriate question.

FOR EXAMINER'S USE		
Section	**Max**	**Mark**
A	**20**	
B	**41**	
C	**29**	
TOTAL	**90**	

This document consists of **21** printed pages and **3** blank pages.

SP (NF/CGW) T28411/9 **[Turn over**

Answer **all** the questions.

Section A

1 The cheetah is the fastest animal on land.
The highest speed reached by a cheetah is recorded as 114 km per hour.

(a) Show that 114 km per hour is about 32 $m\,s^{-1}$.

[1]

(b) The cheetah can accelerate from rest to 114 km per hour in 8.4 s.

Calculate the average acceleration of the cheetah. Express your answer in $m\,s^{-2}$.

average acceleration = ... $m\,s^{-2}$ [2]

2 This question is about the physics of a ball rolling down a hard, smooth ramp onto a horizontal carpet.

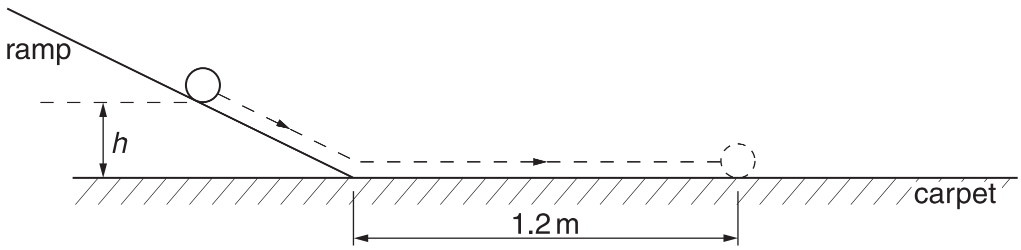

Fig. 2.1

The ball is placed on the ramp at height *h* as shown. The ball is released, rolls down the ramp onto the carpet, and is brought to rest by the frictional force of the carpet after travelling 1.2 m across it.

The experiment is repeated, but this time the ball is released from height 2 *h*.

Estimate the distance travelled across the carpet in the second experiment and show your reasoning clearly.
State any assumption you make.

distance = ... m [3]

3 The conventional filament bulbs used for brake lights in cars are being replaced by light emitting diodes (LEDs). This question looks at one benefit of this technology.

Fig. 3.1

In a test two cars, **A** and **B,** are driven at a constant velocity of $30\,\mathrm{m\,s^{-1}}$ in the same direction along a level road, as shown in Fig. 3.1. The driver of the second car **B** is instructed to apply the brakes as quickly as he can after seeing the brake lights of car **A** come on.

(a) Assuming the reaction time of the driver is 0.6 s, calculate the distance travelled forward by car **B** during the reaction time of the driver.

distance = ... m [1]

(b) An LED takes only one microsecond (1 μs) to light after brakes are pressed, but a filament bulb takes 0.27 seconds. In the test the drivers do not know whether LEDs or filament bulbs have been fitted as brake lights in car **A**.

Calculate the **minimum** distance that the driver of car **B** ought to allow between the cars in order to avoid a collision when the brakes of car **A** are applied in this test.
Explain your reasoning.

distance = ... m [2]

4 This question is about accelerating objects of different mass m using the same constant force F.

Each object starts from rest and is accelerated over the same distance s as shown in Fig. 4.1.

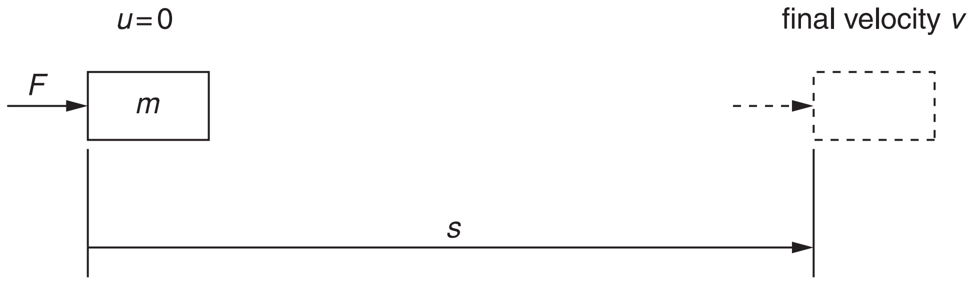

Fig. 4.1

(a) Write down an expression for the acceleration a in terms of force F and mass m.

[1]

(b) Show algebraically that the final velocity v is given by an equation of the form

$$v = \frac{\text{constant}}{\sqrt{m}}$$

and write down an expression for the constant, in terms of F and s.

constant = ... [2]

5 A photomultiplier tube is an electronic device that can be used to detect single photons. Fig. 5.1 shows how the device works.

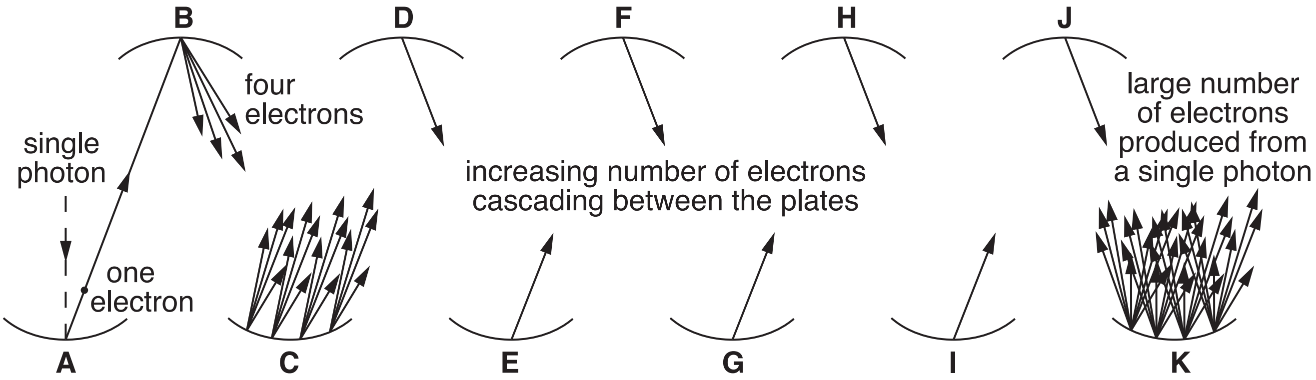

Fig. 5.1

A single photon, incident on metal plate **A,** is absorbed and one electron is released from the metal.
The electron is accelerated from plate **A** until it hits plate **B** with sufficient kinetic energy to release four electrons.
Each of these electrons is accelerated from plate **B** to plate **C**, where each releases four electrons on collision with that plate.

The acceleration process occurs a total of 10 times, as shown in Fig. 5.1.

Calculate the number of electrons that will be emitted from plate **K** when a single photon strikes plate **A** in this photomultiplier tube. Make your reasoning clear.

number of electrons = ... [2]

6 This question compares wave and photon descriptions of the nature of light.
Consider the following situation:

When a laser beam passes through a narrow slit, the beam spreads out and produces broad patches of light on a screen beyond the slit as shown in Fig. 6.1

Fig. 6.1

Complete the table by filling in the missing explanation in each pair.

wave explanation	**quantum explanation**
The energy is carried to the screen by electromagnetic waves.	The energy is carried to the screen by photons.
The energy arrives continuously at the screen.	
The energy of the electromagnetic wave is proportional to $(\text{amplitude})^2$ of the wave.	
	Where the patch of light on the screen is brighter the probability of arrival of photons is greater.

[3]

7 An open pipe and a closed pipe have the same length L.

The fundamental standing wave in the air in each is shown in Fig. 7.1.

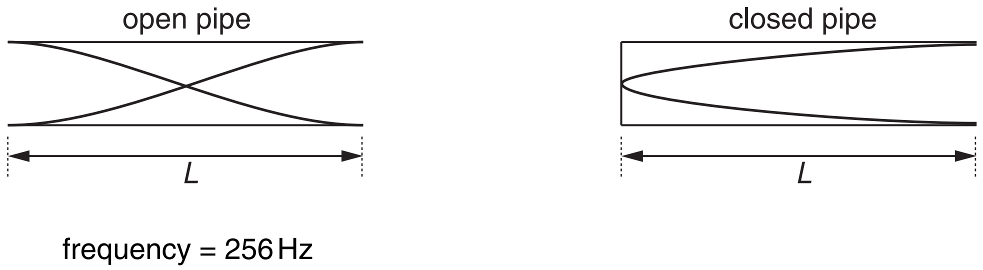

Fig. 7.1

The fundamental note produced in the air in the open pipe has a frequency of 256 Hz.

Calculate the frequency of the fundamental note produced in the closed pipe. Explain your reasoning, stating any assumption that you make.

frequency = ... Hz [3]

[Section A Total: 20]

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Section B

8 This question is about using a diffraction grating to produce a spectrum.

(a) A diffraction grating is labelled 340 lines mm^{-1}.

Show that the slit spacing on the grating is about 3×10^{-6} m.

[2]

(b) A narrow beam of **purple** light passes through the diffraction grating and the pattern of coloured lines shown in Fig. 8.1 is produced on a screen beyond the grating.

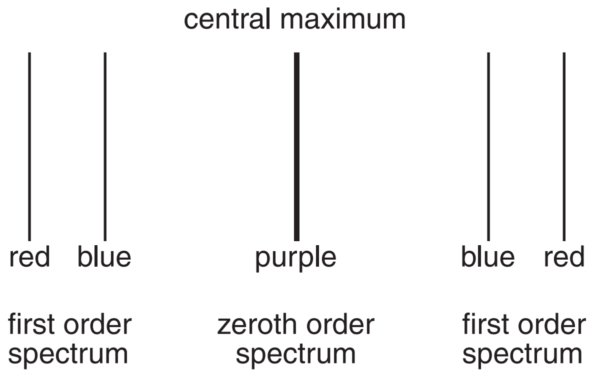


Fig. 8.1

What does the fact that there are only two lines in the first order spectrum tell you about the purple light passing through the grating?

[1]

(c) The blue line in the first order spectrum is produced 0.46 m from the central maximum on a screen placed 3.0 m beyond the grating, as shown in Fig 8.2.

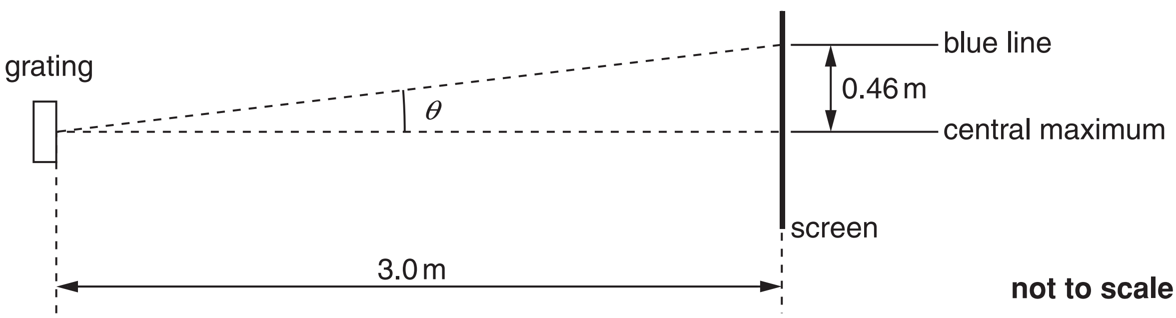


Fig. 8.2

(i) Calculate the angle θ at which the blue line is produced in the first order spectrum.

θ = ... degrees [1]

(ii) Hence show that the wavelength of the blue light is about 450 nm.

[2]

(d) (i) Explain why the red line is further from the central maximum than the blue line, in the first order spectrum.

[2]

(ii) The wavelength of the red light in the beam is 620 nm.

Calculate the distance between the red and blue lines on the screen in the first order spectrum.

distance = ... m [3]

[Total: 11]

9 This question is about the motion of a cricket ball from a bowling machine.

(a) A bowling machine launches a cricket ball horizontally from a height of 3.0 m above the ground, as shown in Fig. 9.1.

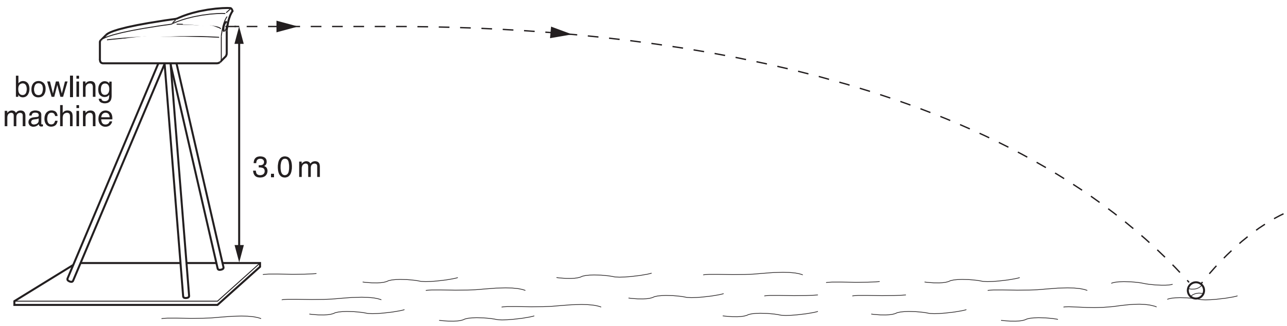
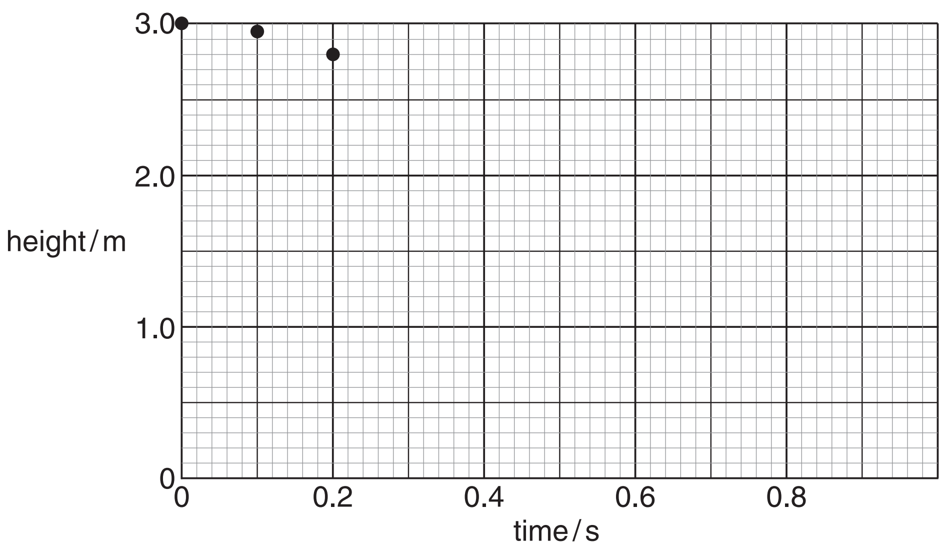


Fig. 9.1

The table shows the height and the horizontal displacement of the ball at various times.

time/s	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7
height/m	3.00	2.95	2.80	2.56	2.22	1.78	1.24	0.60
horizontal displacement/m	0.0	2.5	4.8	6.9	8.8	10.5	12.1	13.6

(i) On the axes of Fig. 9.2 draw a graph to show how the height of the ball above the ground varies with time. The first three points have been plotted for you.



[2]

Fig. 9.2

(ii) State the feature of the graph that shows that the ball is accelerating as it falls. Explain your reasoning.

[2]

(iii) Calculate the time taken for the cricket ball to fall vertically to the ground from a height of 3.0 m, neglecting air resistance.
$g = 9.8\,\text{m}\,\text{s}^{-2}$

time = ... s [2]

(iv) Use the **graph** to show that the vertical motion of the ball is hardly affected at all by air resistance forces.

[1]

(v) Use information from the **table** to show that the horizontal motion of the ball **is significantly** affected by air resistance forces.

[2]

(b) The vertical and horizontal components of velocity of the cricket ball as it reaches the ground are $7.6\,\text{m}\,\text{s}^{-1}$ and $14\,\text{m}\,\text{s}^{-1}$ respectively.

Find the angle to the horizontal at which the ball strikes the ground. Show your working.

angle to horizontal = ... degrees [2]

[Total: 11]

10 This question is about radio waves reflected from the ionosphere.

(a) A transmitter emits waves of frequency 500 kHz.

Calculate the wavelength of these waves.

velocity of electromagnetic radiation = $3.0 \times 10^8\,\mathrm{m\,s^{-1}}$

wavelength = ... m [2]

(b) The radio waves are sent from a transmitter **T** to a receiver **R**. Fig. 10.1 shows two paths for the waves.

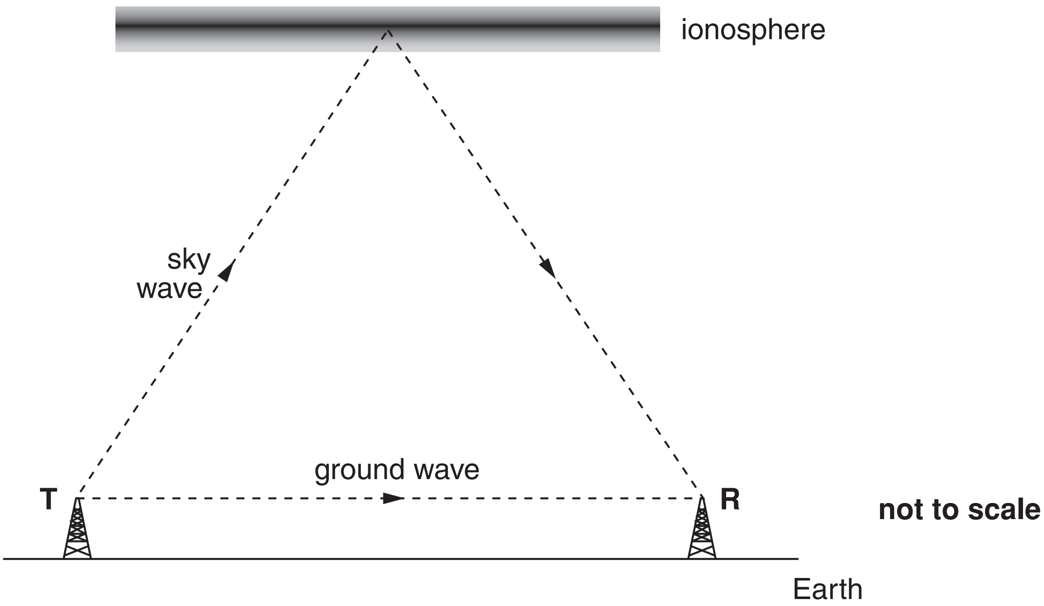


Fig. 10.1

The **ground** wave travels directly from **T** to **R**, but the **sky** wave travels up to the ionosphere and is reflected from it down to **R**. The ionosphere, which reflects radio waves, changes its position above the Earth as conditions in the atmosphere change. When the ionosphere is in the position shown in Fig. 10.1 the signal detected at **R** is a **minimum**.

(i) Explain, in terms of the principle of superposition, how the minimum is caused in this situation.

[2]

(ii) Explain why the minimum is not necessarily zero.

[1]

(iii) When the ionosphere moves a small distance towards the Earth, the signal detected rises to a maximum.

Explain, in terms of the principle of superposition, why there is now a maximum.

[2]

(c) At night, when the atmosphere is cooling down, the ionosphere moves downwards towards the Earth. The movement can be detected by the apparatus shown in Fig. 10.2.

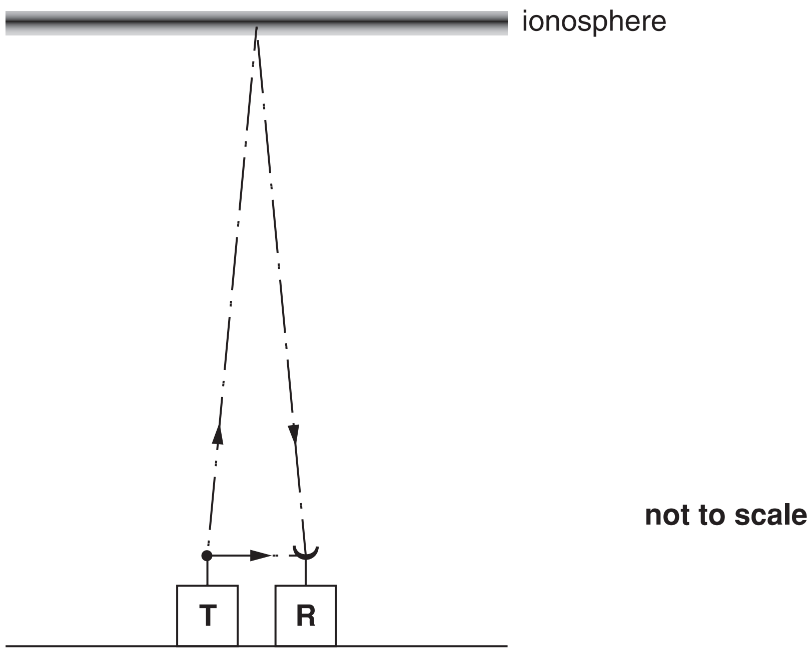


Fig. 10.2

Fig. 10.2 shows the path from **T** to **R** followed by a wave reflecting from the ionosphere.
In addition, some of the wave from **T** goes directly to **R** where the two waves combine to give the resultant signal.
During the early evening the signal at the receiver fades to a minimum every 15 minutes.

Calculate the speed at which the ionosphere is descending towards the Earth.
Make your reasoning clear.

wavelength of radio wave = 600 m.

speed = ... $m\,s^{-1}$ [3]

[Total: 10]

11 A new type of efficient light bulb emits photons only at two frequencies, in the red and green regions of the visible spectrum.

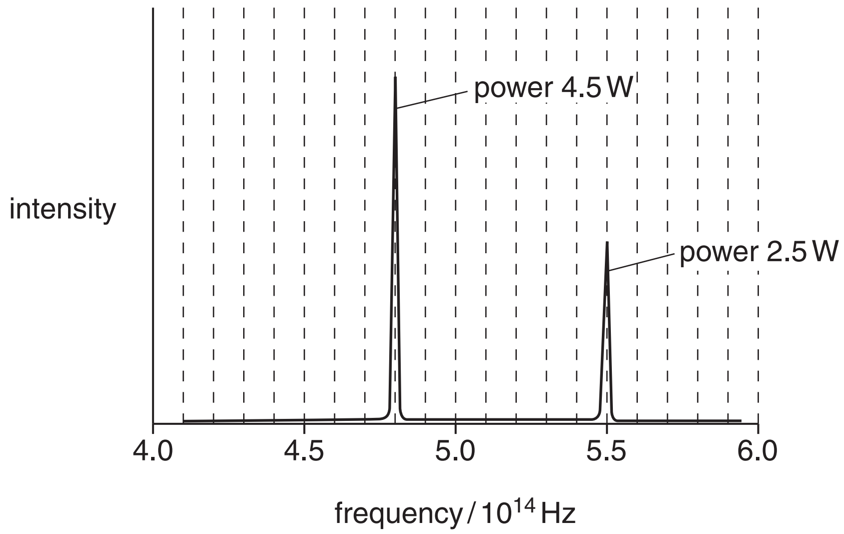


Fig. 11.1

Fig 11.1 shows the intensity distribution in the spectrum of light given out by the bulb.

(a) The light bulb is 70% efficient and draws 10 W from the electrical supply.

(i) Explain what is meant by the statement "The light bulb is 70% efficient".

[1]

(ii) Use information from Fig. 11.1 to show that the efficiency of this 10 W bulb is 70%.

[2]

(b) **(i)** Calculate the energy of a photon of the red light emitted by the bulb.
the Planck constant = 6.6×10^{-34} J s

energy = ... J [2]

(ii) Calculate the energy of a photon of the green light emitted by the bulb.

energy = ... J [1]

(c) Using information from Fig. 11.1, and your answers to **(b)**, show that the bulb emits about **twice** as many photons of red light as photons of green light, every second.

[3]

[Total: 9]

[Section B Total: 41]

Section C

In this section, you will choose the context in which you give your answers.

Use diagrams to help your explanations and take particular care with your written English. In this section, four marks are available for the quality of written communication.

12 In this question you are to write about one method of generating and observing standing waves.

(a) State the example of standing waves that you have chosen.

[1]

(b) Draw a diagram to show the arrangement of apparatus required to generate these standing waves. Label the important features on your diagram.

[4]

(c) Describe how you would generate your standing wave.

[2]

(d) **(i)** Sketch a standing wave that could be produced in the situation that you have described. Label the positions of any displacement nodes and antinodes with the letters **N** and **A** respectively.

[2]

(ii) Use your knowledge of physics to explain how this standing wave is produced.

[2]

(e) Describe what changes you would need to make to your apparatus to generate a different standing wave pattern. Sketch the new standing wave pattern.

[2]

[Total: 13]

13 In this question you are to write a short account of a method to measure the distance to a remote, or inaccessible, object of interest. In such situations, direct measurement of the distance by ruler or tape measure is impossible.

(a) (i) State the distance measurement to be made.

[1]

(ii) Give an estimate of the distance to be measured.

distance = ... unit .... [1]

(b) (i) Draw a diagram to show how the apparatus is to be arranged to make the measurement. Label the important features on the diagram.

[4]

(ii) Describe how your method works and what data are collected.

[3]

(c) Explain how the data obtained can be used to find the distance to the object of interest.

[3]

[Total: 12]

Quality of Written Communication [4]

[Section C Total: 29]

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