Centre Number						Candidate Number				
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Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
3	
4	
TOTAL	

General Certificate of Education
Advanced Level Examination
June 2012

Physics A PHYA5/2D

Unit 5D Turning Points in Physics
Section B

Monday 18 June 2012 9.00 am to 10.45 am

For this paper you must have:
- a calculator
- a ruler
- a Data and Formulae Booklet (enclosed).

Time allowed
- The total time for both sections of this paper is 1 hour 45 minutes. You are advised to spend approximately 50 minutes on this section.

Instructions
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- Do all rough work in this book. Cross through any work you do not want to be marked.
- Show all your working.

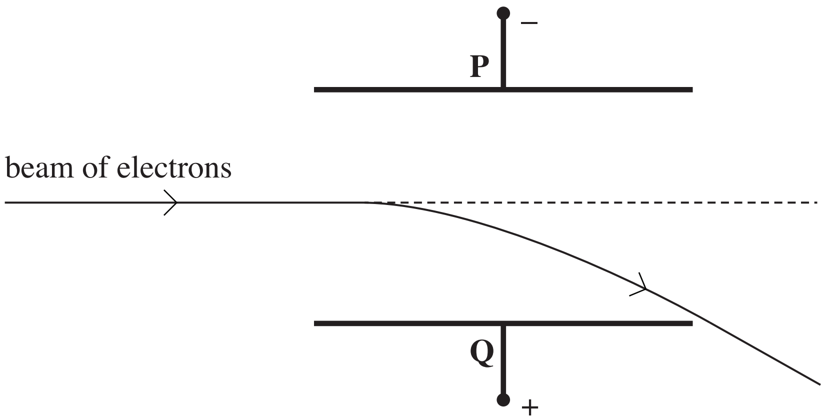
Information
- The marks for questions are shown in brackets.
- The maximum mark for this section is 35.
- You are expected to use a calculator where appropriate.
- A *Data and Formulae Booklet* is provided as a loose insert.
- You will be marked on your ability to:
  – use good English
  – organise information clearly
  – use specialist vocabulary where appropriate.

Section B

The maximum mark for this section is 35 marks. You are advised to spend approximately 50 minutes on this section.

1 A narrow beam of electrons is directed into the region between two parallel plates, **P** and **Q**. When a constant potential difference is applied between the two plates, the beam curves downwards towards plate **Q** as shown in **Figure 1**.

Figure 1



1 (a) Explain why the beam curves downwards at an increasing angle to its initial direction.

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(3 marks)

1 (b) A uniform magnetic field is then applied at right angles to both the beam and the electric field between the plates **P** and **Q**. As a result, the downward deflection of the beam is increased.

1 (b) (i) The arrangement is to be used to determine the speed of the electrons in the beam. Describe what adjustments to the flux density *B* of the magnetic field should be made to reduce the deflection of the beam to zero.

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(1 mark)

1 (b) (ii) Explain why the electrons pass undeflected through the fields when their speed v is given by

$$v = \frac{V}{Bd}$$

where V is the potential difference between plates **P** and **Q** and d is the perpendicular distance between the plates.

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(2 marks)

1 (c) The beam of electrons was produced by thermionic emission from a heated filament. When the potential difference between the anode and the filament was 4200 V, the speed of the electrons in the beam was $3.9 \times 10^7\ \mathrm{m\,s^{-1}}$.

Use this information to determine the specific charge of the electron.

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answer = ... $\mathrm{C\,kg^{-1}}$

(3 marks)

9

2 (a) Describe, in terms of electric and magnetic fields, a plane polarised electromagnetic wave travelling in a vacuum. You may wish to draw a labelled diagram.

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(3 marks)

2 (b) In his theory of electromagnetic waves, Maxwell predicted that the speed of all electromagnetic waves travelling through free space is given by

$$c = \frac{1}{\sqrt{\mu_o \varepsilon_o}}$$

where μ_o is the permeability of free space and ε_o is the permittivity of free space.

Explain why this prediction led to the conclusion that light waves are electromagnetic waves.

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(2 marks)

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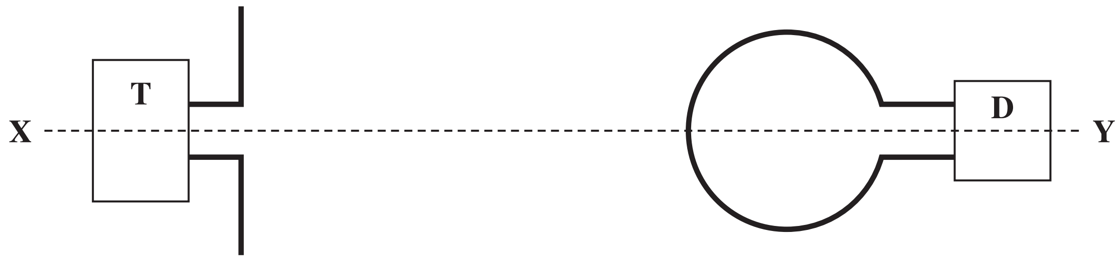
2 (c) Hertz discovered how to produce and detect radio waves. **Figure 2** shows a transmitter of radio waves, **T**, and a detector **D**. The detector loop and the transmitter aerial are in the same vertical plane.

Figure 2



2 (c) (i) Explain why an alternating emf is induced in the loop when it is in this position.

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(3 marks)

2 (c) (ii) Explain why an alternating emf **cannot** be detected if the detector loop is turned through 90^{o} about the axis **XY**.

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(1 mark)

9

3 (a) Light has a dual wave-particle nature. State and outline a piece of evidence for the wave nature of light and a piece of evidence for its particle nature. For each piece of evidence, outline a characteristic feature that has been observed or measured and give a short explanation of its relevance to your answer. Details of experiments are not required.

The quality of your written communication will be assessed in your answer.

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(6 marks)

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3 (b) An electron is travelling at a speed of $0.890\,c$ where c is the speed of light in free space.

3 (b) (i) Show that the electron has a de Broglie wavelength of 1.24×10^{-12} m.

(2 marks)

3 (b) (ii) Calculate the energy of a photon of wavelength 1.24×10^{-12} m.

answer = ... J

(1 mark)

3 (b) (iii) Calculate the kinetic energy of an electron with a de Broglie wavelength of 1.24×10^{-12} m.
Give your answer to an appropriate number of significant figures.

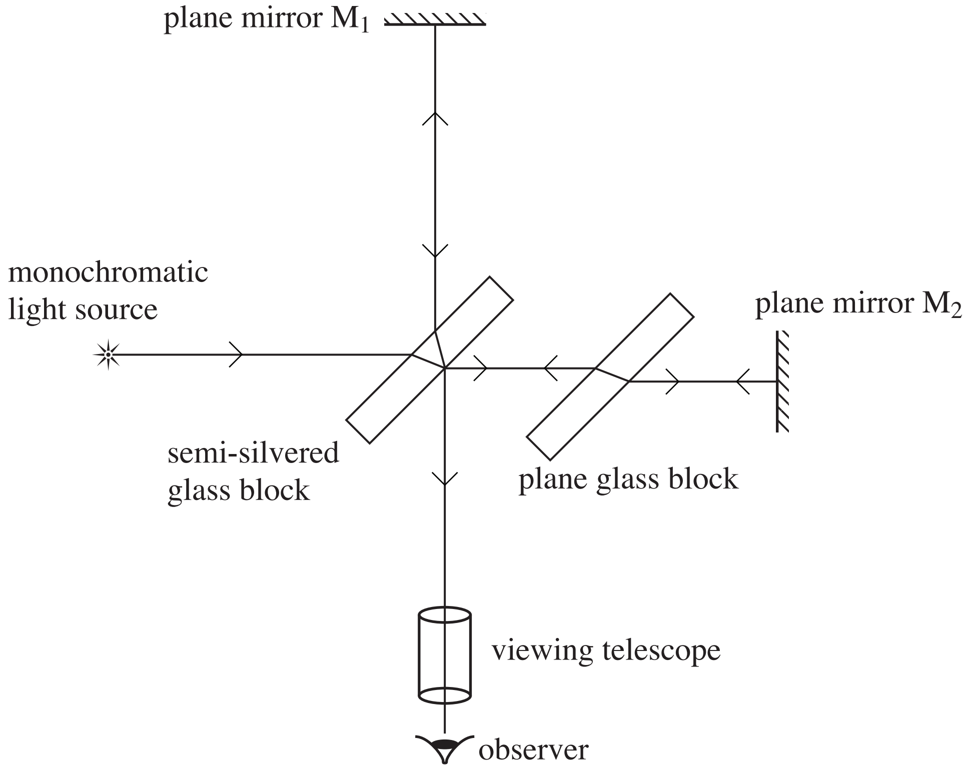
answer = ... J

(2 marks)

11

4 **Figure 3** represents the Michelson-Morley interferometer. Interference fringes are seen by an observer looking through the viewing telescope.

Figure 3



4 (a) Explain why the interference fringes shift their position if the distance from either of the two mirrors to the semi-silvered block is changed.

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(2 marks)

4 (b) Michelson and Morley predicted that the interference fringes would shift when the apparatus was rotated through 90°. When they tested their prediction, no such fringe shift was observed.

4 (b) (i) Why was it predicted that a shift of the fringes would be observed?

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(3 marks)

4 (b) (ii) What conclusion was drawn from the observation that the fringes did not shift?

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(1 mark)

6

END OF QUESTIONS

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