Centre Number						Candidate Number				
Surname										
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 2010

Physics A PHYA5/2D

Unit 5D Turning Points in Physics
Section B

Tuesday 29 June 2010 1.30 pm to 3.15 pm

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

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.

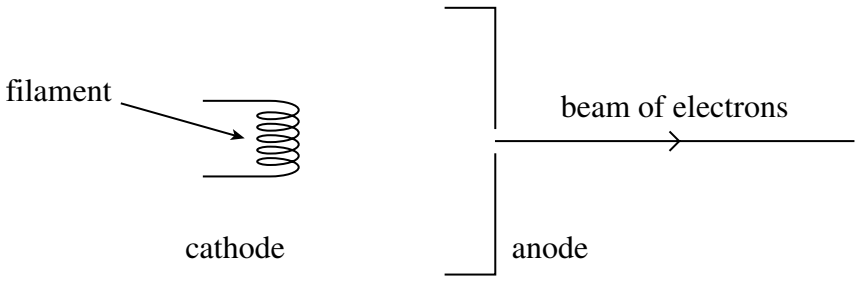
Information
- The marks for questions are shown in brackets.
- The maximum mark for this section is 35.
- You are expected to use a calculator where appropriate.
- A *Data and Formulae Booklet* is provided as a loose insert.
- You will be marked on your ability to:
  – use good English
  – organise information 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 produced in a vacuum tube using an electron gun, part of which is shown in **Figure 1**.

Figure 1



1 (a) (i) State and explain the effect on the beam of electrons of increasing the filament current.

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(2 marks)

1 (a) (ii) State and explain the effect on the beam of electrons of increasing the anode potential.

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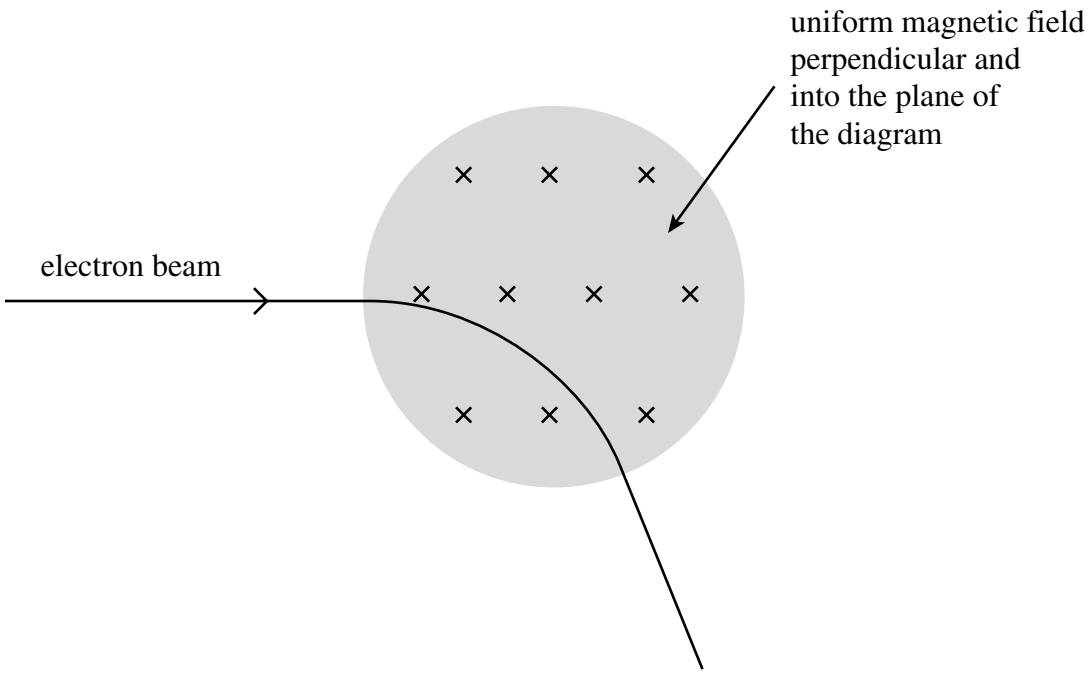
(2 marks)

1 (b) The beam of electrons is directed at right angles into a uniform magnetic field as shown in **Figure 2**.

Figure 2



1 (b) (i) Explain why the electrons move in a circular path at a constant speed in the magnetic field.

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(3 marks)

Question 1 continues on the next page

1 (b) (ii) When the speed of the electrons in the beam is $7.4 \times 10^6\,\text{m s}^{-1}$ and the magnetic flux density is 0.60 mT, the radius of curvature of the beam is 68 mm.

Use these data to calculate the specific charge of the electron, stating an appropriate unit. Give your answer to an appropriate number of significant figures.

answer = ...

(4 marks)

1 (b) (iii) Discuss the historical relevance of the value of the specific charge of the electron compared with the specific charge of the H^+ ion.

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(2 marks)

13

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ANSWER IN THE SPACES PROVIDED

2 When light of wavelength 590 nm is directed at an uncharged surface of a certain metal X, electrons are emitted from the metal surface causing a photoelectric current.

2 (a) When the metal surface is charged positively, the photoelectric current decreases and becomes zero when the potential of the surface is + 0.35 V.

2 (a) (i) Calculate the maximum kinetic energy of a photoelectron emitted from the surface when the metal surface is uncharged.

answer = ... J

(2 marks)

2 (a) (ii) Calculate the work function of the metal surface, in J.

answer = ... J

(3 marks)

2 (b) When the experiment was repeated using a different metal, Y, illuminated by light of the same wavelength, there was no photoelectric emission when the metal surface was uncharged.

2 (b) (i) Explain this observation.

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(2 marks)

2 (b) (ii) How did this observation contribute to the failure of the wave theory of light?

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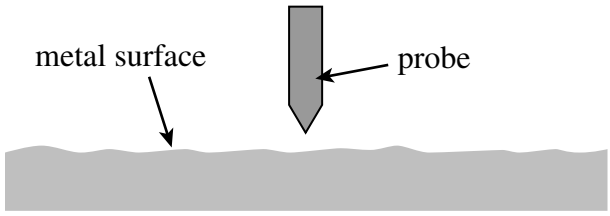
(2 marks)

9

Turn over for the next question

3 **Figure 3** shows the probe of a scanning tunnelling microscope (STM) above a metal surface.

Figure 3



3 (a) Explain why electrons can cross the gap between the tip of the probe and the surface, provided

- the gap is sufficiently narrow
- a potential difference is applied between the tip and the surface.

The quality of your written communication will be assessed in this question.

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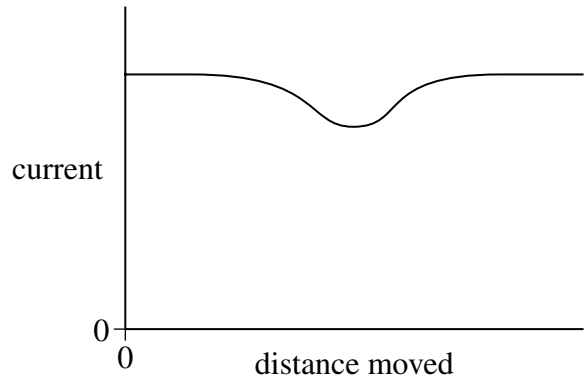
(6 marks)

3 (b) The probe is moved horizontally in a straight line across the surface. As it moves, the current due to the transfer of electrons between the surface and the probe decreases then returns to its initial value at the end of the line, as shown in **Figure 4**.

Figure 4



Explain why the current changes in this way.

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(2 marks)

8

Turn over for the next question

4 (a) One of the two postulates of Einstein's theory of special relativity is that the speed of light in free space, c, is invariant.

Explain what is meant by this statement.

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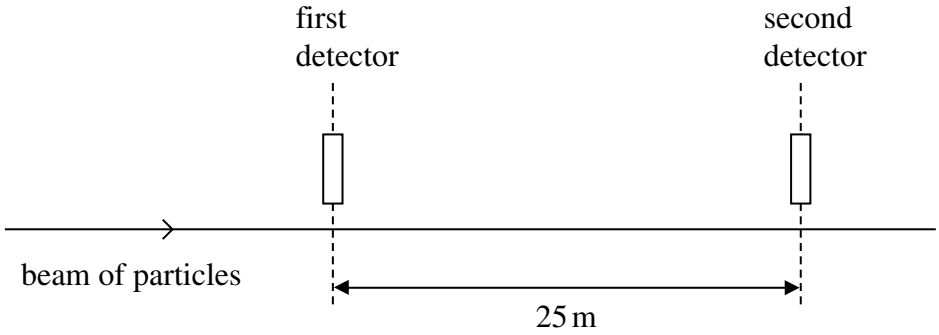
(1 mark)

4 (b) A beam of identical particles moving at a speed of $0.98c$ is directed along a straight line between two detectors 25 m apart.

Figure 5



The particles are unstable and the intensity of the beam at the second detector is a quarter of the intensity at the first detector.

Calculate the half-life of the particles in their rest frame.

answer = ... s

(4 marks)

END OF QUESTIONS

5

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