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 2014

Physics A PHYA5/2D

Unit 5D Turning Points in Physics
Section B

Thursday 19 June 2014 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.

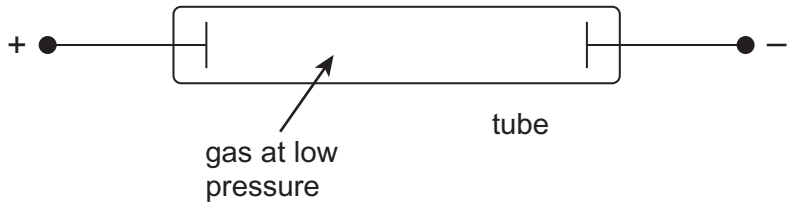
Information
- The marks for questions are shown in brackets.
- The maximum mark for this section is 35.
- You are expected to use a calculator where appropriate.
- A *Data and Formulae Booklet* is provided as a loose insert.
- You will be marked on your ability to:
  – use good English
  – organise information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

Section B

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

1 **Figure 1** shows a discharge tube containing a gas at low pressure. When a sufficiently high potential difference is applied between the two electrodes in the tube the gas becomes conducting and emits light.

Figure 1



1 (a) (i) Describe how the charged particles responsible for conduction in the gas are produced.

[2 marks]

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1 (a) (ii) Explain why the gas emits light and why it must be at low pressure.

[3 marks]

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1 (b) The charged particles moving towards the negative electrode were initially referred to as positive rays. Explain why their **specific charge** depends on the choice of gas in the tube.

[2 marks]

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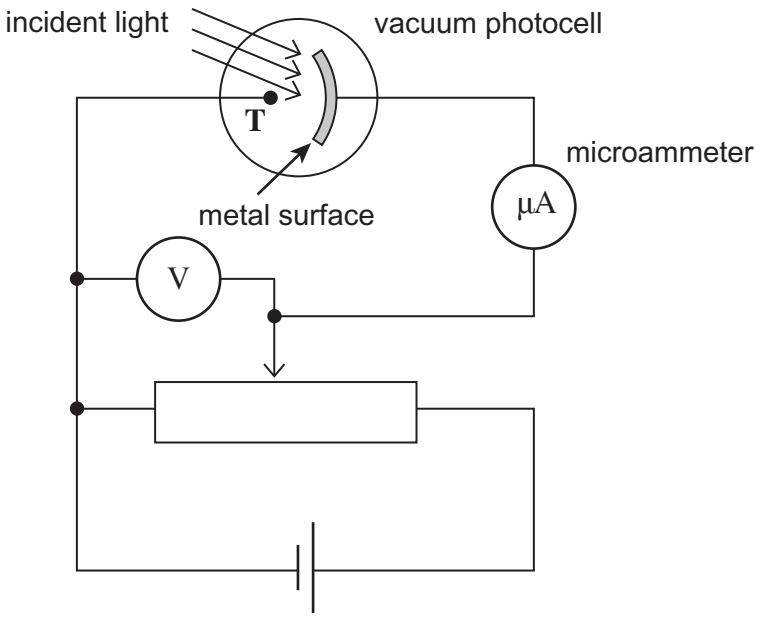
7

Turn over for the next question

2 **Figure 2** shows a metal surface in a vacuum photocell illuminated by light of a certain frequency. Electrons emitted from the metal surface are collected by terminal **T** in the photocell.

Figure 2



2 (a) The potential of the metal surface may be changed by adjusting the potential divider. Explain why the microammeter reading decreases when the metal surface is made more positive relative to **T**.

[3 marks]

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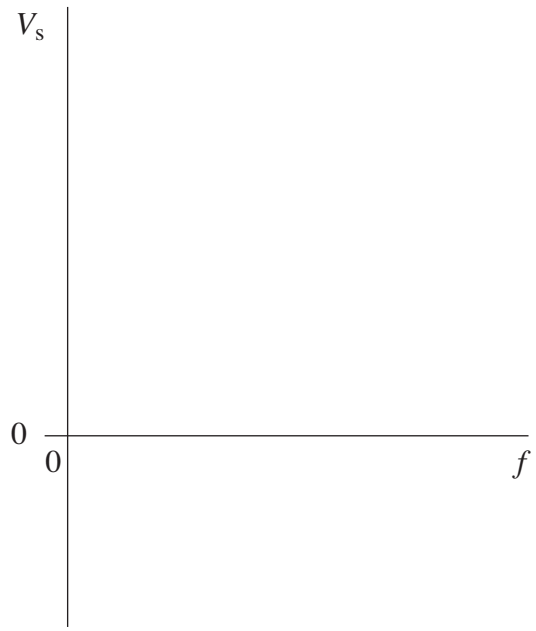
2 (b) The stopping potential V_s is the minimum potential that is applied to the metal surface to reduce the photoelectric current to zero when monochromatic light is incident on the surface. The circuit is used with light of different frequencies to measure the stopping potential V_s when the surface is illuminated at each frequency.

2 (b) (i) Draw a graph on the axes below to show how V_s varies with the frequency f of the incident light.

[2 marks]



2 (b) (ii) Use the photoelectric equation $hf = \phi + E_k$ to explain your graph.

[3 marks]

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Question 2 continues on the next page

2 (c) Using the circuit in **Figure 2**, the stopping potential was $1.92\,\text{V}$ for light of wavelength $418\,\text{nm}$.
Use this information to calculate the work function of the metal surface.
Give an appropriate unit in your answer.

[4 marks]

work function ..... unit .....

12

3 (a) A transmission electron microscope (TEM) contains magnetic lenses that form an image of a thin sample when a beam of electrons passes through the sample.

3 (a) (i) Explain why a magnetic lens deflects the electrons without changing their kinetic energy.

[2 marks]

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3 (a) (ii) Calculate the de Broglie wavelength of the electrons in the beam of a TEM in which the anode potential is $21\,\mathrm{kV}$.
Give your answer to an appropriate number of significant figures.

[3 marks]

wavelength ..... m

Question 3 continues on the next page

3 (b) In the operation of a TEM, electrons pass through a thin sample and form a magnified image of the sample on a fluorescent screen.

Describe the physical processes that the electrons are subjected to between the sample and the screen. In your account, you should discuss the relevant particle-like and wave-like properties of electrons in relation to

- the sample
- the deflection and focusing of the electron beam
- the screen
- the magnification and the quality of the image.

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

[6 marks]

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11

Turn over for the next question

4 (a) One of the two postulates of Einstein's theory of special relativity is that physical laws have the same form in all inertial frames of reference. Explain in terms of velocity what is meant by an inertial frame of reference.

[1 mark]

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4 (b) Light takes 4.3 years to reach the Earth from the star Alpha Centauri.

4 (b) (i) A space probe is to be sent from the Earth to the star to arrive 5.0 years later, according to an observer on Earth.
Assuming the space probe's velocity is constant, calculate its speed in $\mathrm{m\,s^{-1}}$ on this journey.

[1 mark]

speed ..... $\mathrm{m\,s^{-1}}$

4 (b) (ii) Calculate the time taken for this journey in years registered by a clock in the space probe.

[3 marks]

time taken ..... years

5

END OF QUESTIONS

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