Please write clearly in block capitals.

Centre number | | | | | | Candidate number | | | | |

Surname _____

Forename(s) _____

Candidate signature _____

A-level PHYSICS

Paper 3BD – Turning Points in Physics

Specimen materials (set 2)

Time allowed: The total time for both sections of this paper is 2 hours. You are advised to spend approximately 50 minutes on this section.

Materials

For this paper you must have:
- a pencil
- a ruler
- a scientific calculator
- a Data and Formulae booklet.

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 paper is 35.
- You are expected to use a calculator where appropriate.
- A Data and Formulae Booklet is provided as a loose insert.

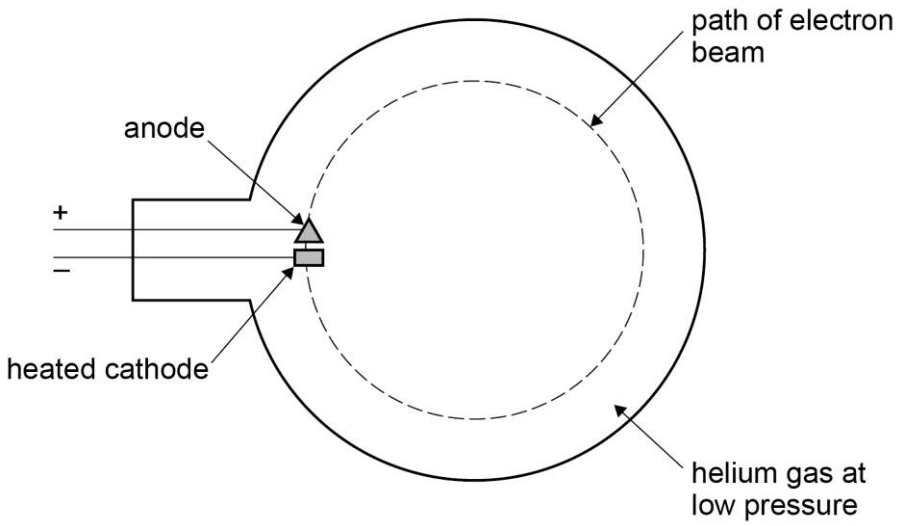
For examiner's use	
Question	Mark
1	
2	
3	
4	
TOTAL	

Section B

Answer **all** question(s) in this section.

0 1 **Figure 1** shows part of an apparatus used to determine the specific charge of an electron.

Figure 1



Electrons are emitted by the cathode by thermionic emission. They are accelerated by the potential difference between the cathode and anode. The tube contains helium gas at a low pressure and the gas emits light to show the path of the electron beam.

The beam is bent into a circular path by applying a magnetic field perpendicular to the plane of the diagram.

0 1 . 1 Explain how light is emitted as the electrons travel through the helium gas.

[3 marks]

0 1 . 2 In one experiment the potential difference between the cathode and anode is $2.5\ \text{kV}$.

Show that the speed of the electrons is about $3.0 \times 10^{7}\ \text{m s}^{-1}$.

[2 marks]

0 1 . 3 When the flux density of the magnetic field is $3.1\ \text{mT}$ the diameter of the path of the beam is $0.114\ \text{m}$.

Calculate the value for the specific charge of an electron from the data in this experiment.

[3 marks]

specific charge = _____ C kg^{-1}

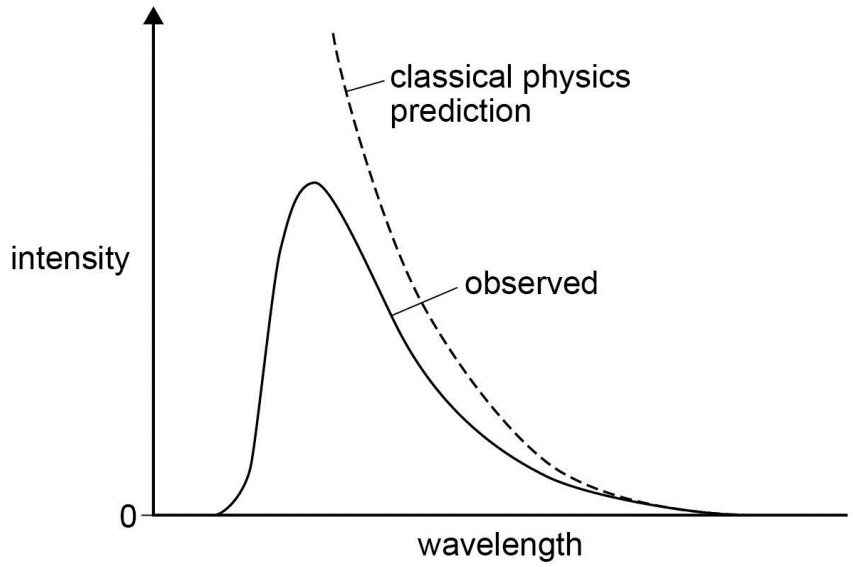
0 1 . 4 In practice the path of the electron beam is not a perfect circle.

Discuss how the presence of the gas affects the path of the electrons.

[3 marks]

0 2 The solid line on the graph in **Figure 2** shows how the intensity of radiation from a black body varies with wavelength at a particular temperature. The dotted line shows the variation as predicted by classical physics.

Figure 2



0 2 . 1 Explain why the difference between the predicted and experimental curves is called the ultraviolet catastrophe.

[2 marks]

0 2 . 2 Describe the difference between the classical physics view and the quantum theory proposal made by Max Planck that enabled the distribution of the shape of the intensity–wavelength graph to be correctly predicted.

[2 marks]

0 2 . 3 Discuss the evidence that the photoelectric effect provides in support of the quantum theory.

[3 marks]

7

Turn over for the next question

0 3 . 1 Bertozzi's experiment was designed to test the relationship between the kinetic energy of an electron and its speed as predicted by the theory of special relativity.

Describe Bertozzi's experiment.

Your answer should include:

- a diagram of the experimental arrangement
- details of how the kinetic energy and the speed were measured.

[6 marks]

0 3 . 2 A scientist conducts an experiment similar to Bertozzi's experiment and reports that when the electron speed is $2.93 \times 10^8 \text{ m s}^{-1}$ the measured kinetic energy is 2.4 MeV.

Determine whether these data are consistent with the result expected using the theory of special relativity.

[4 marks]

0 4 In a transmission electron microscope (TEM) electrons are accelerated by a potential difference V between a cathode and anode. The de Broglie wavelength λ of the accelerated electrons depends on V.

0 4 . 1 Identify which of the following represents the relationship between λ and V. Ignore relativistic effects.

Tick (✓) the correct answer in the right-hand column

[1 mark]

	✓ if correct
$\lambda \propto \sqrt{V}$	
$\lambda \propto V$	
$\lambda \propto \frac{1}{V}$	
$\lambda \propto \frac{1}{\sqrt{V}}$	

0 4 . 2 TEM's operate using wavelengths of about $0.1\ \text{nm}$.

Explain why operation at such wavelengths makes the instrument such an important research tool.

[2 marks]

Question 4 continues on the next page

0 4 . 3 State and explain **two** factors that limit the detail in the image produce by a TEM.

[4 marks]

1 _____

_____

_____

_____

2 _____

_____

_____

_____

7

END OF QUESTIONS