Please write clearly in block capitals.

Centre number | | | | | |

Candidate number | | | | |

Surname ______________________________

Forename(s) ______________________________

Candidate signature ______________________________

I declare this is my own work.

A-level PHYSICS

Paper 3
Section B Turning points in physics

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 and a ruler
- a scientific calculator
- a Data and Formulae Booklet
- a protractor.

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.
- If you need extra space for your answer(s), use the lined pages at the end of this book. Write the question number against your answer(s).
- 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 scientific 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	

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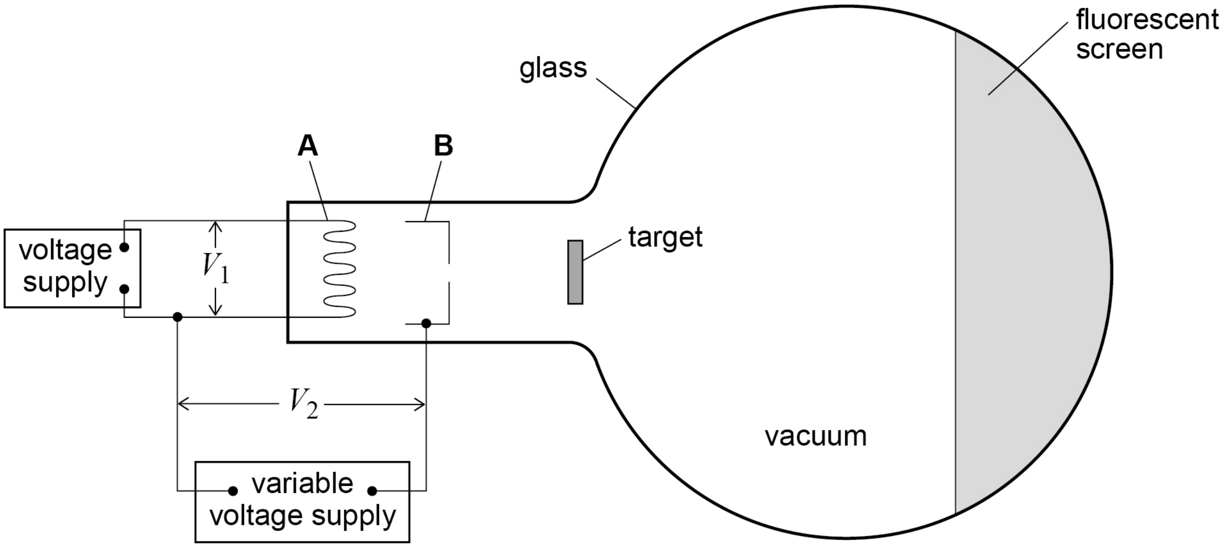
Section B

Answer **all** questions in this section.

0 1 **Figure 1** shows the apparatus used in an experiment to investigate electron diffraction and the de Broglie hypothesis.

Figure 1



0 1 . 1 Explain how high-speed electrons are produced in the apparatus in **Figure 1**.

In your answer you should:

- name parts **A** and **B**
- discuss the purposes of potential differences V_1 and V_2.

[4 marks]

0 1 . 2 In the experiment, electrons are incident on a target made of a crystalline material. The electron wavelengths need to be about 50% the size of an atom to produce a diffraction pattern on the screen.

Suggest a suitable value for V_2.
Support your answer with a calculation.

[4 marks]

V_2 = ______________________ V

Question 1 continues on the next page

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0 1 . 3 **Figure 2** shows a typical diffraction pattern produced on the screen by the electrons.

Figure 2

Explain how measurements made with the apparatus in **Figure 1** can be used to support the de Broglie hypothesis.

[4 marks]

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0 1 . 4 STM and TEM are abbreviations for two types of electron microscope.

Which row links the type of microscope to a relevant property of moving electrons?
Tick (✓) **one** box.

[1 mark]

STM	TEM	
Moving electrons can cross a potential barrier.	Moving electrons can be deflected by a magnetic field.	☐
Moving electrons can be deflected by a magnetic field.	Moving electrons can be deflected by a magnetic field.	☐
Moving electrons can be deflected by a magnetic field.	Moving electrons can cross a potential barrier.	☐
Moving electrons can cross a potential barrier.	Moving electrons can cross a potential barrier.	☐

13

Turn over for the next question

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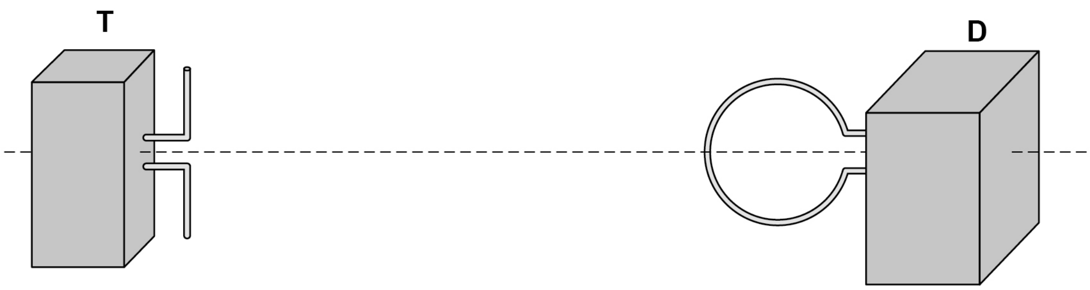
0 2 In 1864, James Clerk Maxwell published a theory that included an equation for the speed of electromagnetic waves in a vacuum.

0 2 . 1 Show that Maxwell's theory agrees with the accepted value for the speed of light in a vacuum.
Use information from the Data and Formulae Booklet in your answer.

[2 marks]

Between 1886 and 1889, Heinrich Hertz completed a series of experiments in an attempt to verify Maxwell's theory. **Figure 3** shows a simplified arrangement similar to the one used by Hertz in one of his experiments.

Figure 3



T is a radio wave transmitter with an aerial consisting of two vertical metal rods.
D is a detector that uses a conducting loop aerial.

Do not write outside the box

0 2 . 2 **T** is switched on so that an oscillating current is produced in the metal rods.
An emf is detected in the conducting loop aerial.

Explain this experiment with reference to Maxwell's model of electromagnetic waves.
[4 marks]

Question 2 continues on the next page

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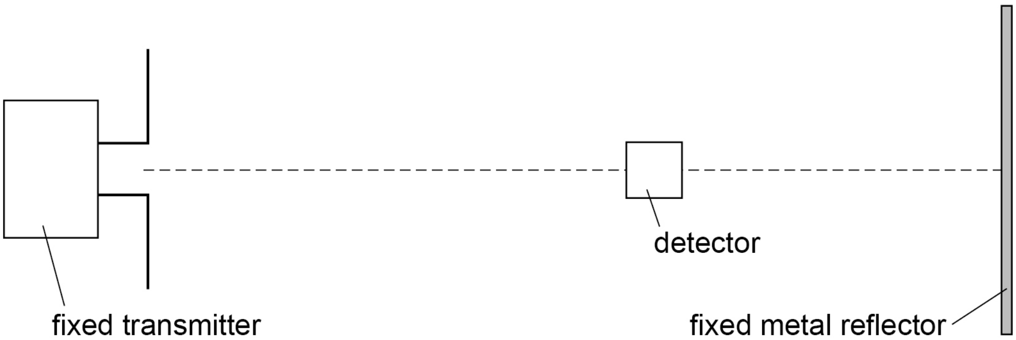
0 2 . 3 In a different experiment Hertz used stationary waves to determine the speed of radio waves.
Figure 4 shows an experimental arrangement similar to the arrangement Hertz used.

Figure 4



Stationary waves are produced between the fixed transmitter and the fixed metal reflector.

In one experiment the distance between the transmitter and reflector is about $12\ \text{m}$ and the transmitter frequency is $75\ \text{MHz}$.

Deduce whether this arrangement can be used to measure the speed of electromagnetic waves suggested by Maxwell's equation.

[4 marks]

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10

Turn over for the next question

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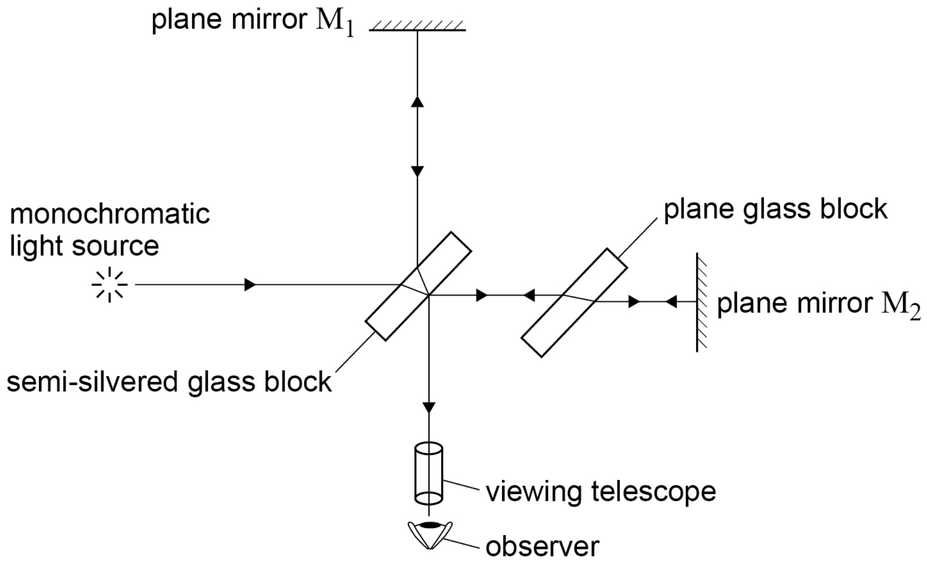
0 3 **Figure 5** shows the features of a Michelson-Morley interferometer.

Figure 5



Explain how, using this arrangement, Michelson and Morley attempted to detect the absolute motion of the Earth.

In your answer you should:

- outline the experimental procedure
- explain the expected result of the experiment
- describe the actual result and explain the significance of this result.

[6 marks]

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6

Turn over for the next question

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0 4 . 1 State what is meant by an inertial frame of reference.

[1 mark]

0 4 . 2 A pair of detectors is set up to measure the intensity of a parallel beam of unstable particles.
In the reference frame of the laboratory, the detectors are separated by a distance of $45\ \text{m}$. The speed of the particles in the beam is $0.97c$.

The intensity of the beam at the second detector is 12.5% of the intensity at the first detector.

Calculate the half-life of the particles in the reference frame in which they are at rest.

[4 marks]

half-life = ____________________ s

0 4 . 3 In calculations involving time dilation, it is important to identify proper time.

Identify the proper time in the calculation in Question **04.2**.

[1 mark]

6

END OF QUESTIONS

There are no questions printed on this page

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