A

AQA

Surname _____

Other Names _____

Centre Number _____

Candidate Number _____

Candidate Signature _____

I declare this is my own work.

A-level

PHYSICS

Paper 3

Section B Turning points in physics

7408/3BD

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.

At the top of the page, write your surname and other names, your centre number, your candidate number and add your signature.

[Turn over]

JUN227408 3BD 01

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.**
- **Answer ALL questions.**
- **You must answer the questions in the spaces provided. Do not write 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.**

DO NOT TURN OVER UNTIL TOLD TO DO SO

SECTION B

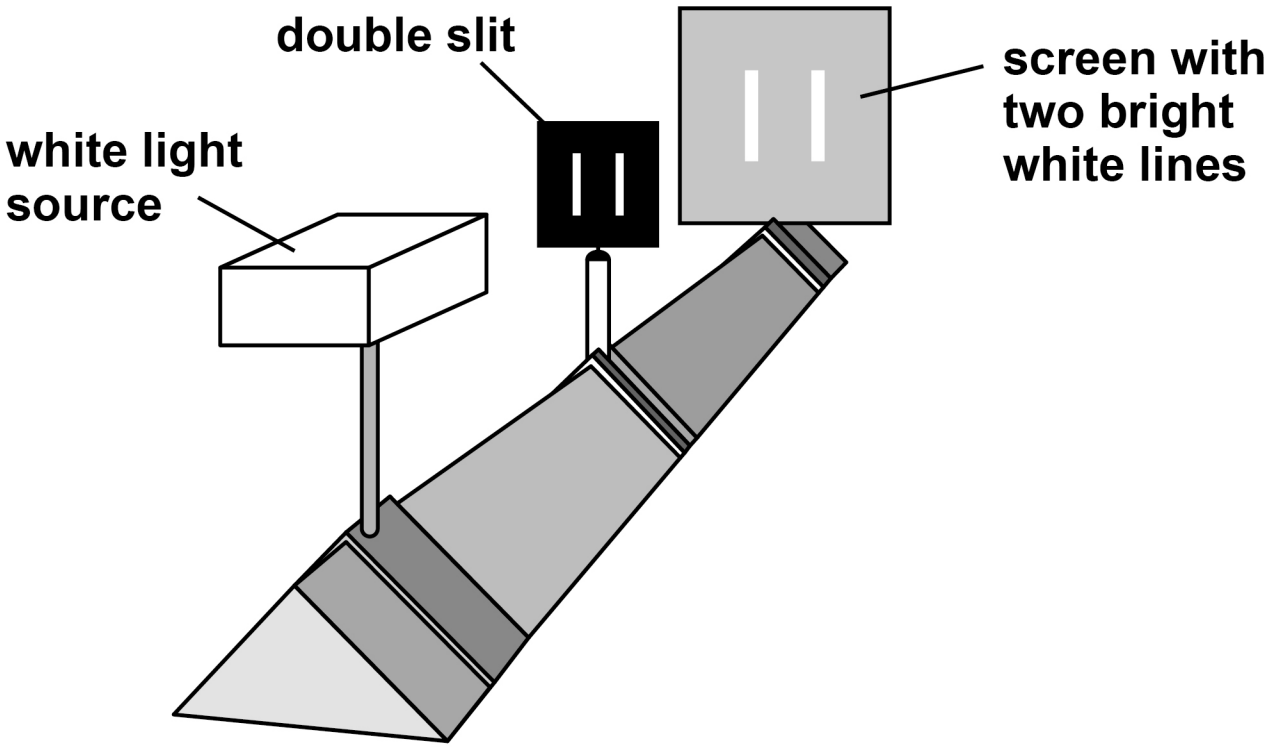
Answer ALL questions in this section.

0 1

In the 17th century, Isaac Newton proposed a theory to explain some of the properties of light. An alternative theory of light was proposed by Christiaan Huygens at about the same time.

A student uses the arrangement in FIGURE 1 to investigate the two theories.

FIGURE 1



0 1 . 1

The student observes two bright white lines on the screen.

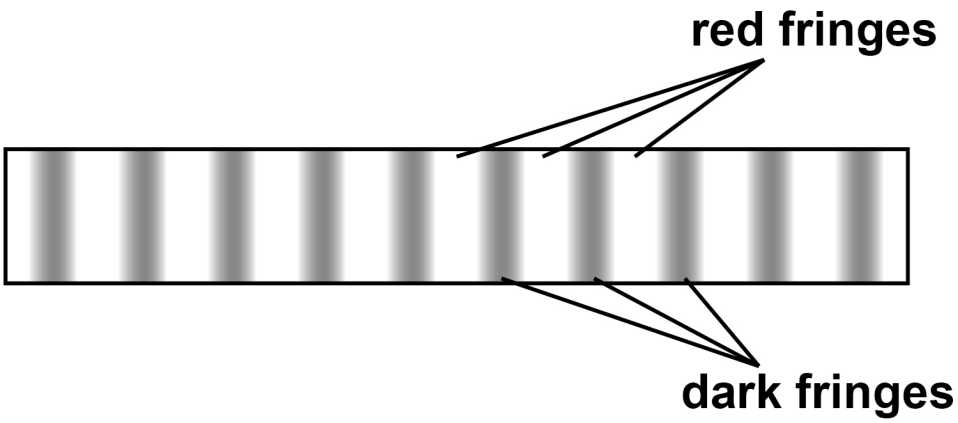
Explain how this observation supports Newton's theory of light. [2 marks]

0 1 . 2

The student makes alterations to the apparatus in FIGURE 1, on page 4.

FIGURE 2 shows the red and dark fringes that the student now observes on the screen.

FIGURE 2



Identify the alterations made by the student and explain how the observations in FIGURE 2 support Huygens' theory of light.

In your answer you should:

- **identify alterations made to the apparatus in FIGURE 1**
- **outline the key features of Huygens' theory**
- **explain how the result of this experiment supports Huygens' theory.**

[6 marks]

[Turn over]

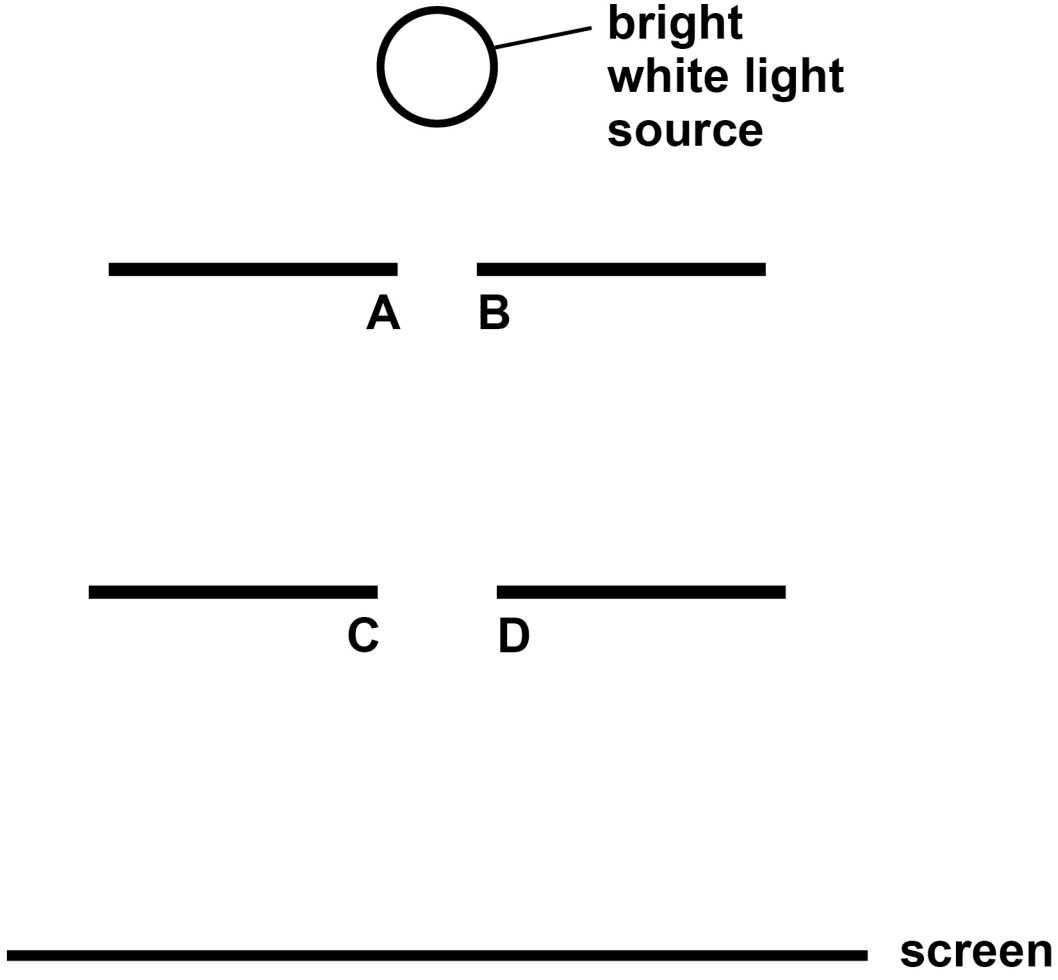
[Turn over]

[Turn over]

0 1 . 3

Shortly before the work of Newton and Huygens, Francesco Grimaldi carried out an experiment into the behaviour of light. FIGURE 3 shows Grimaldi's arrangement.

FIGURE 3



A bright white light source is used to illuminate a small circular aperture, AB. The light from this aperture illuminates a second, slightly larger circular aperture, CD.

The light passing through both apertures arrives at a screen.

Newton's theory and Huygens' theory make different predictions about the appearance of the light on the screen.

Discuss these differences in appearance. [3 marks]

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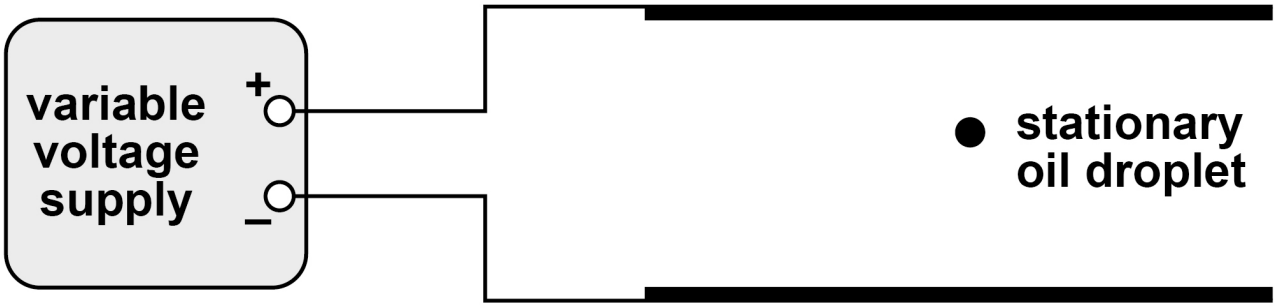
[Turn over]

0 2

Robert Millikan experimented with oil drops to determine a value for the electronic charge.

FIGURE 4 shows a stationary oil droplet between two horizontal metal plates. The plates are connected to a variable voltage supply so that the upper plate is positive. The oil droplet has mass m and charge Q.

FIGURE 4



0 2 . 1

State and explain the sign of the charge on the oil droplet. [1 mark]

The variable voltage supply is set to zero volts. The oil drop falls. The constant speed v_1 of the falling oil droplet is found to be 3.8×10^{-5} m s^{-1} and the following measurements are recorded:

density of oil = 910 kg m^{-3}
viscosity of air = 1.8×10^{-5} N s m^{-2}

0 2 . 2

Show that the mass m of the oil droplet is about 8×10^{-16} kg. [3 marks]

[Turn over]

0 2 . 3

The variable voltage supply is adjusted so that the oil droplet rises at a constant speed v_2. The potential difference (pd) across the plates is V and the distance between the plates is d.

In his experiment, Millikan measured the constant speed v_1 of a falling droplet when the pd was zero. He compared this with the speed v_2 of the same droplet when the droplet was made to rise.

Show that $\frac{v_2}{v_1} = \frac{VQ}{dmg} - 1$

[2 marks]

0 2 . 4

The following measurements are made for the droplet in Question 02.2 when it is rising at constant speed.

$V = 715\ \text{V}$

$v_2 = 1.1 \times 10^{-4}\ \text{m s}^{-1}$

The separation of the plates $d = 11.6\ \text{mm}$.

Deduce, using the equation in Question 02.3, whether the value of the charge for this droplet is consistent with the currently accepted value of the electronic charge. [3 marks]

0 2 . 5

After Millikan published his results, it was found that he had used a value for the viscosity of air that was smaller than the actual value.

Discuss the effect this error had on Millikan's value of the electronic charge. [3 marks]

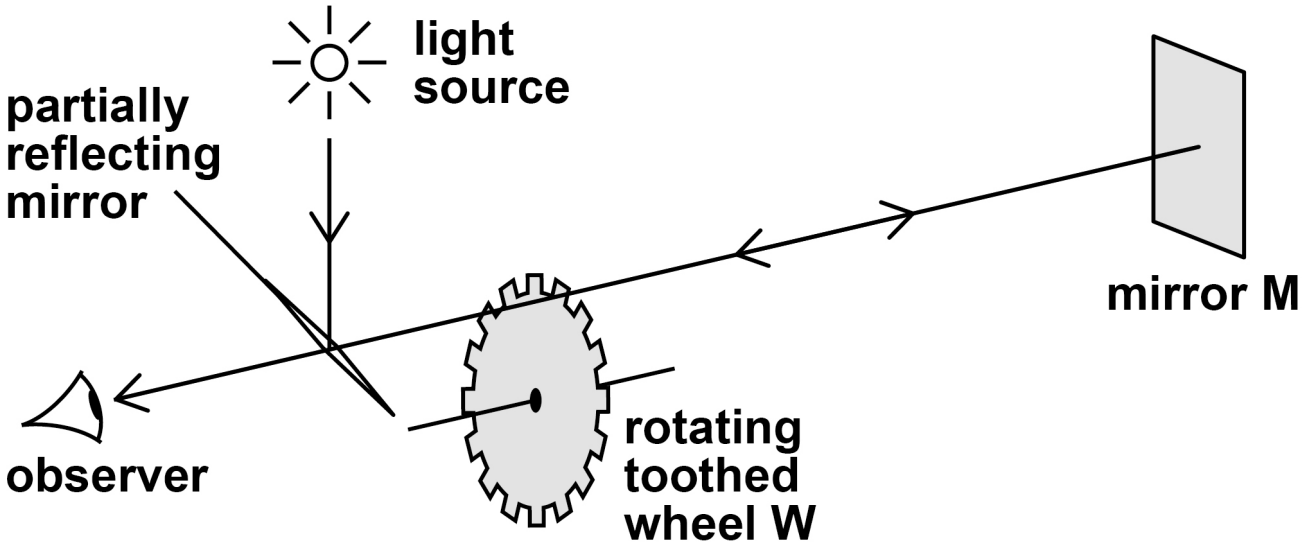
[Turn over]

12

0 3

FIGURE 5 shows the arrangement used by Fizeau to determine the speed of light.

FIGURE 5



The toothed wheel W is rotated and the reflected light from a distant mirror M is observed.

The speed of light is calculated from the equation

$$c = 4dnf_0$$

where d is the distance from W to M and

n is the number of teeth on the rotating wheel W.

0 3 . 1

State what f_0 represents in the equation. [2 marks]

[Turn over]

0 3 . 2

The experiment is attempted using a rotating wheel with 720 teeth that can be rotated at up to 620 revolutions per minute.

The distance between W and M is $8.5\ \text{km}$.

Deduce whether the speed of light can be determined with this particular arrangement. [2 marks]

0 3 . 3

The determination of the speed of light took on extra significance when Maxwell derived the wave-speed equation

$$c = \frac{1}{\sqrt{\varepsilon_0 \mu_0}}$$

State how ε_0 and μ_0 are related to the types of field in the wave. [2 marks]

ε_0 _____

_____

_____

_____

μ_0 _____

_____

_____

_____

[Turn over]

6

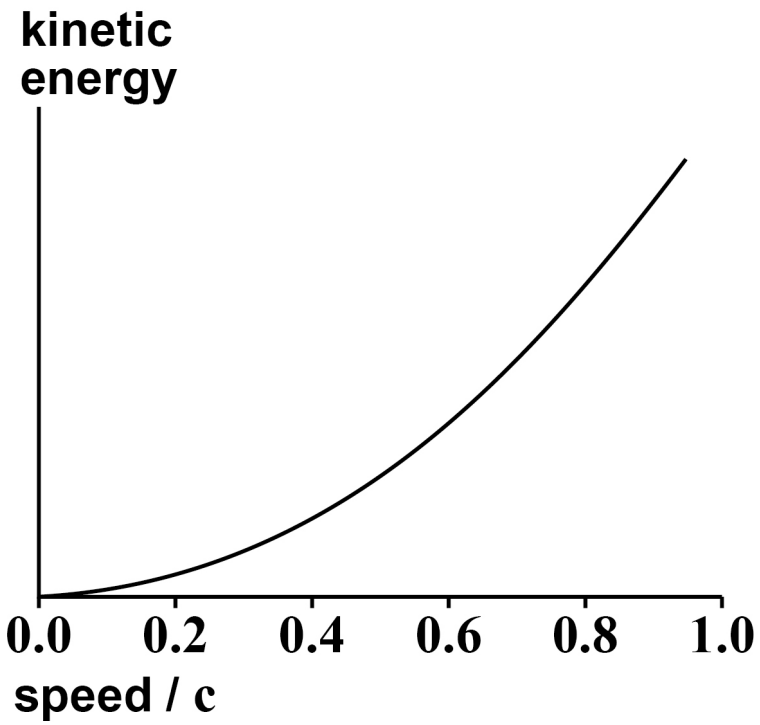
0 4 . 1

Bertozzi investigated how the kinetic energy of electrons varies with speed.

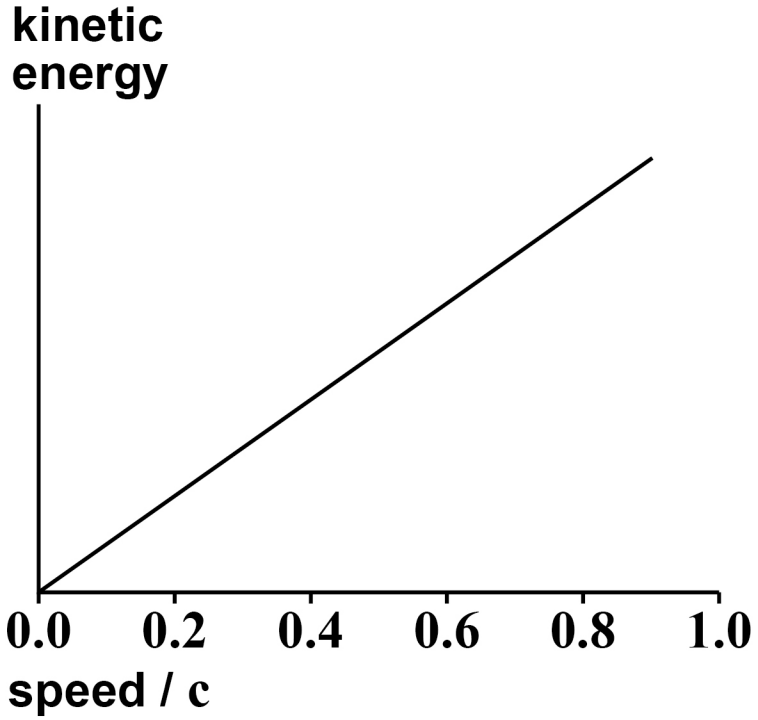
Which graph, on pages 26 to 28, shows the variation of kinetic energy with speed? [1 mark]

Tick (✓) ONE box.

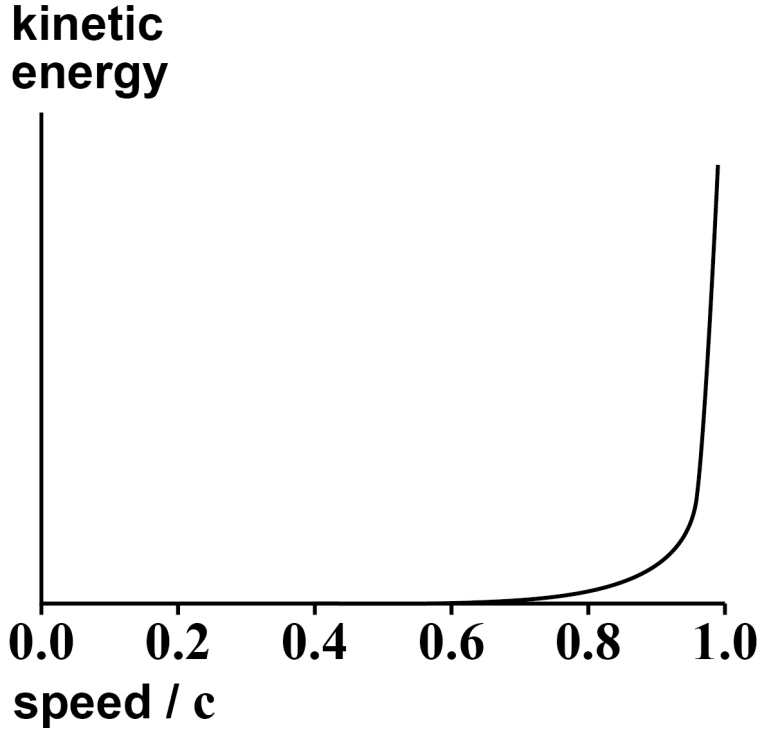
☐ **A**



B

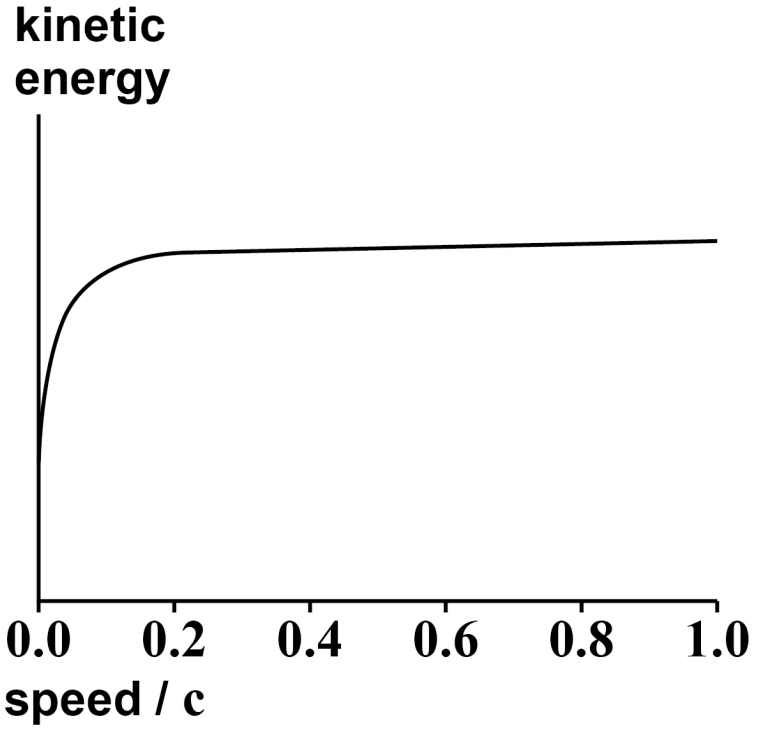

kinetic energy
0.0
0.2
0.4
0.6
0.8
1.0
speed / c

C


kinetic energy
0.0
0.2
0.4
0.6
0.8
1.0
speed / c

[Turn over]

D



0 4 . 2

Calculate the speed of a particle when its kinetic energy is equal to its rest energy. [3 marks]

speed = _____ m s^{-1}

[Turn over]

0 4 . 3

Discuss the change in the observed mass of a spring when it is stretched. [2 marks]

END OF QUESTIONS

6

Additional page, if required.

Write the question numbers in the left-hand margin.

Additional page, if required.
Write the question numbers in the left-hand margin.

Additional page, if required.
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For Examiner's Use	
Question	Mark
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2	
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