A

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

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

[Turn over]

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.

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

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SECTION B

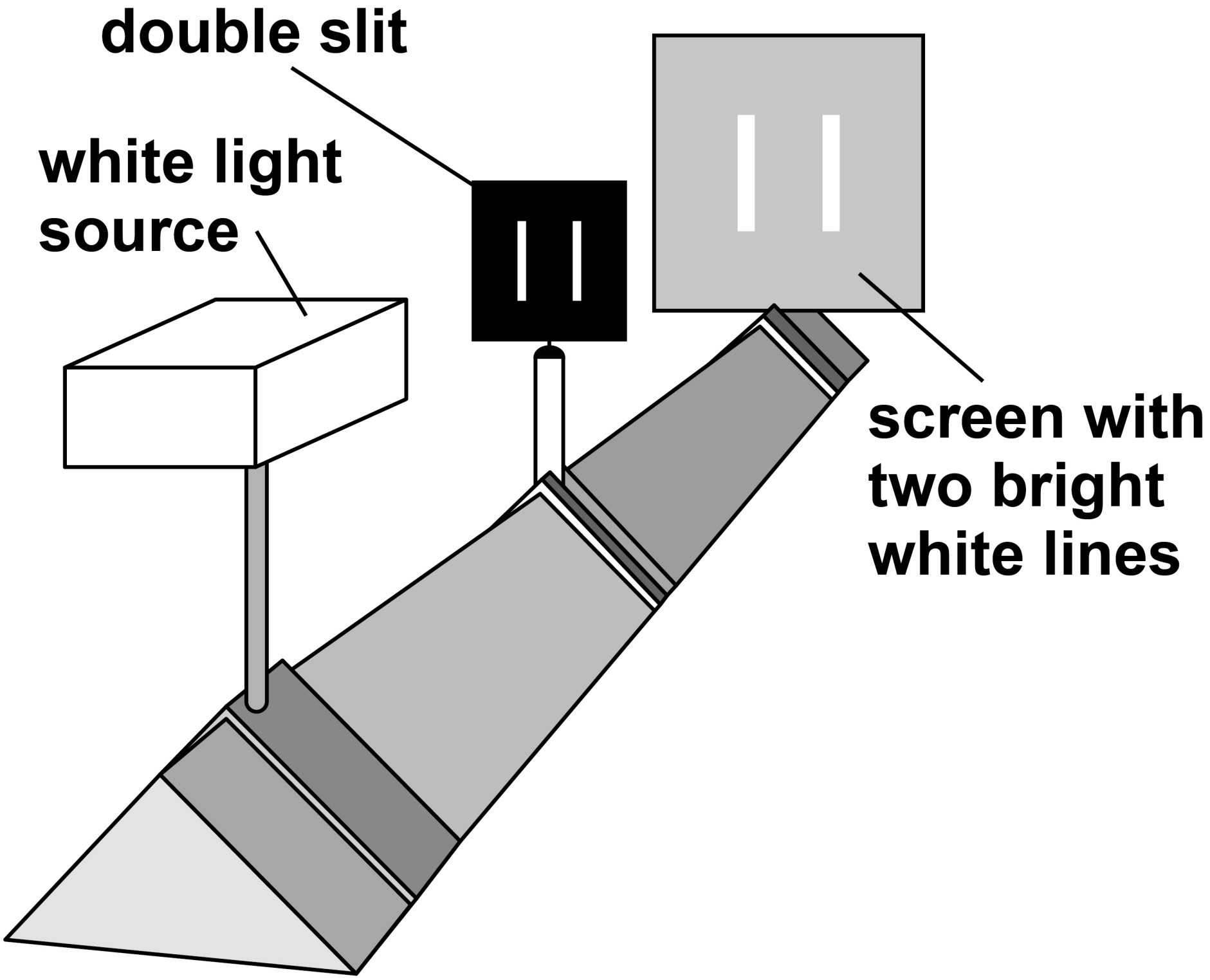
Answer ALL questions in this section.

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, on page 6, to investigate the two theories.

FIGURE 1


double slit
white light source
screen with two bright white lines

0 1 . 1

The student observes two bright white lines on the screen.

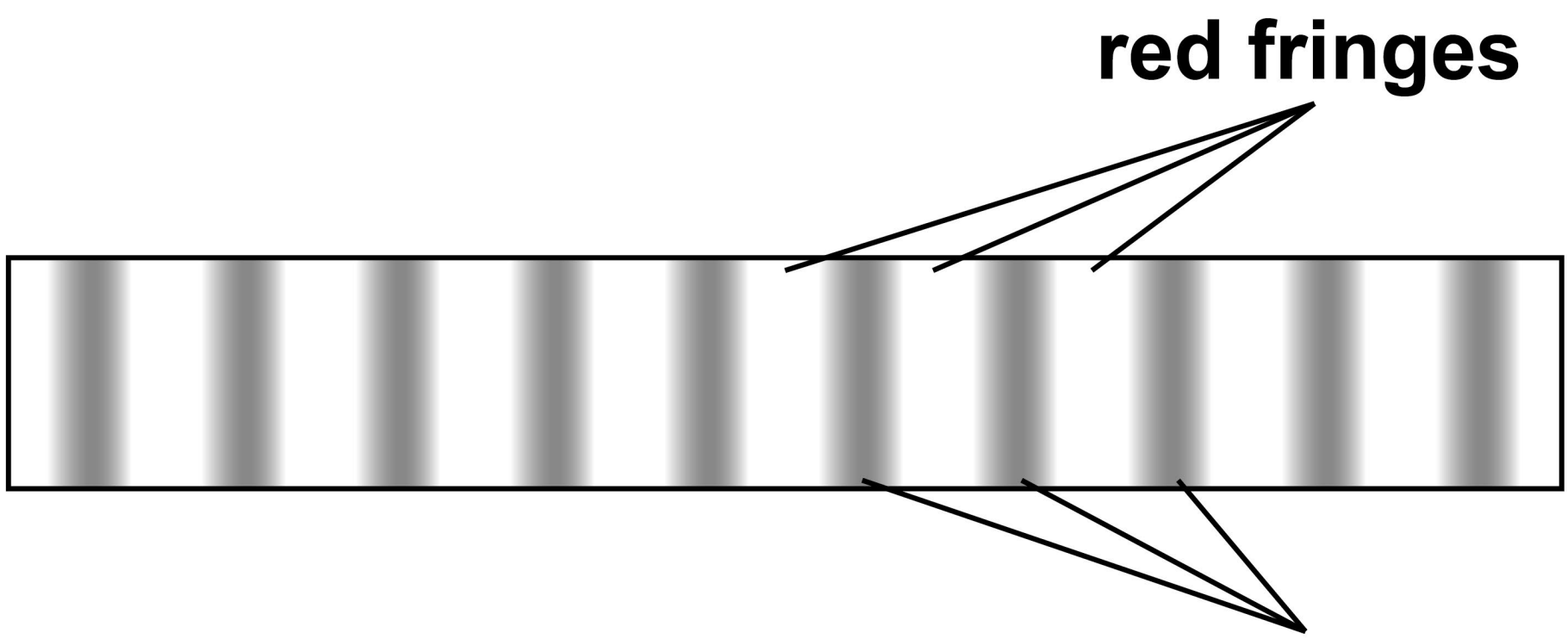
Explain how this observation supports Newton's theory of light. [2 marks]

0 1 . 2

The student makes alterations to the apparatus in FIGURE 1, on page 6.

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]

0 1 . 3

Shortly before the work of Newton and Huygens, Francesco Grimaldi carried out an experiment into the behaviour of light. FIGURE 3, on page 16, shows Grimaldi's arrangement.

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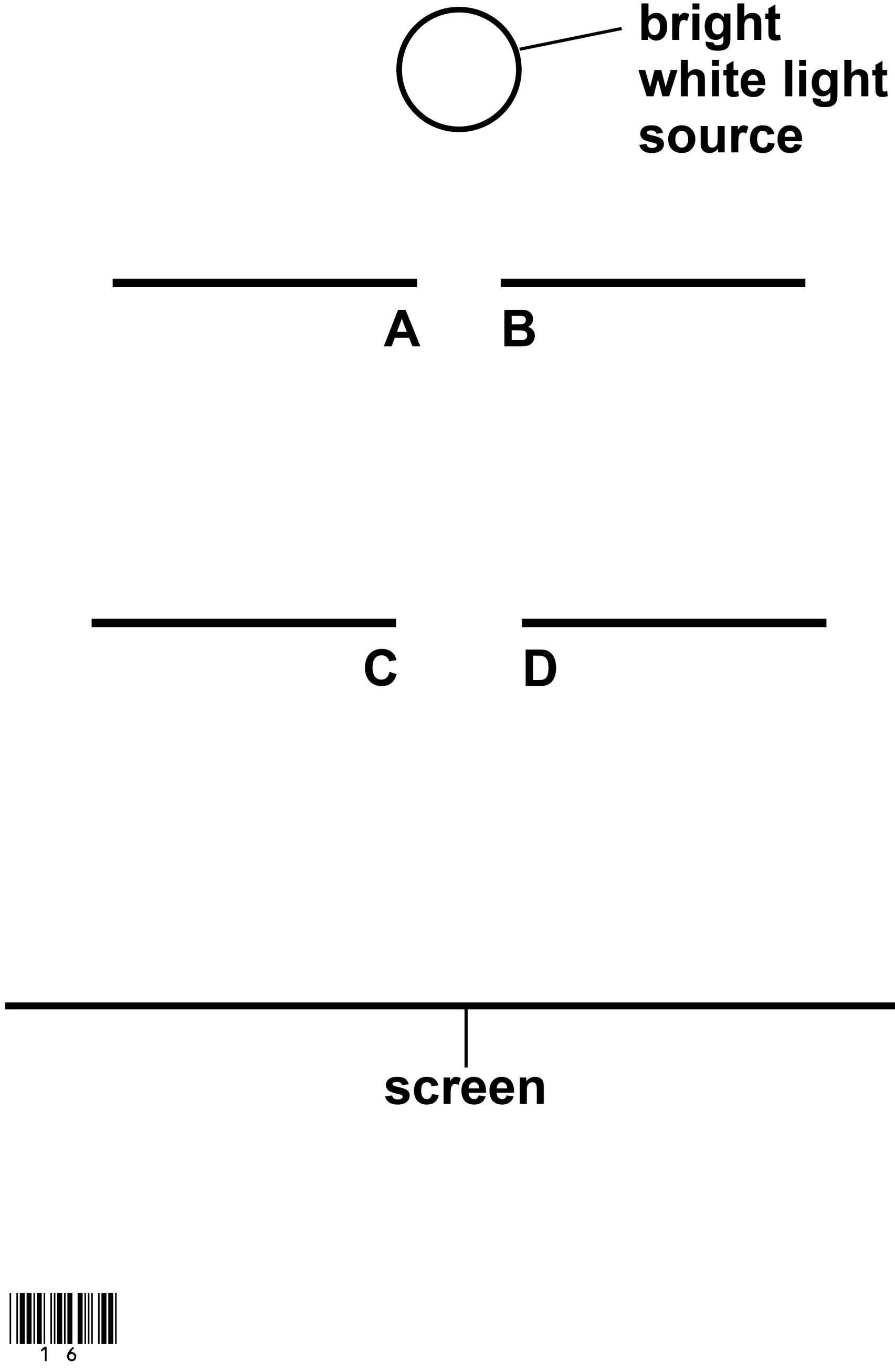
FIGURE 3



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]

11

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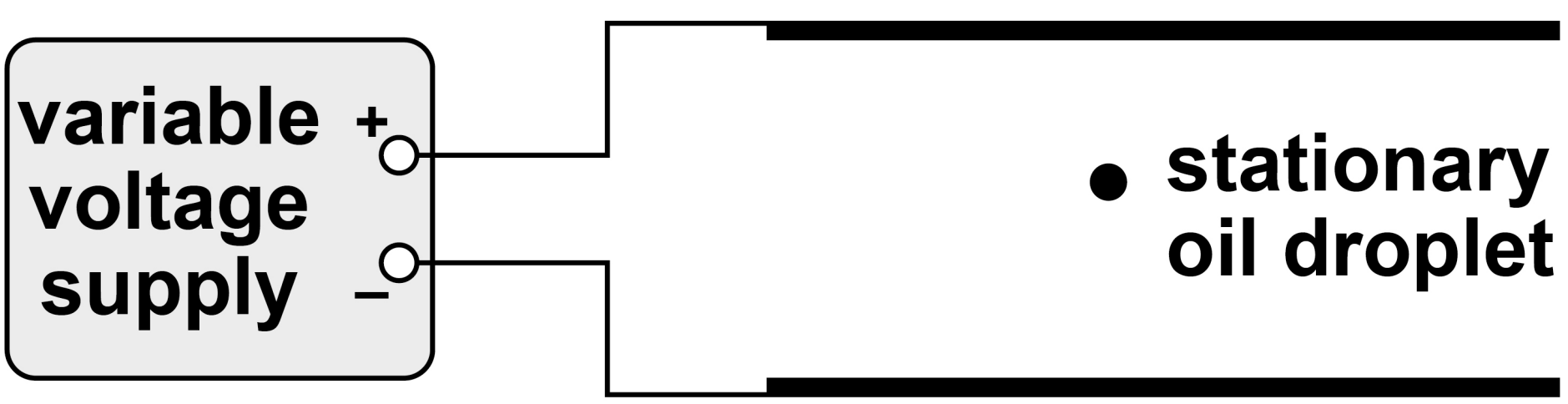
[Turn over]

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 $3.8 \times 10^{-5}\ \text{m s}^{-1}$ and the following measurements are recorded:

density of oil = $910\ \text{kg m}^{-3}$

viscosity of air = $1.8 \times 10^{-5}\ \text{N s m}^{-2}$

0 2 . 2

Show that the mass m of the oil droplet is about $8 \times 10^{-16}\ \text{kg}$. [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]

[Turn over]

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]

[Turn over]

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]

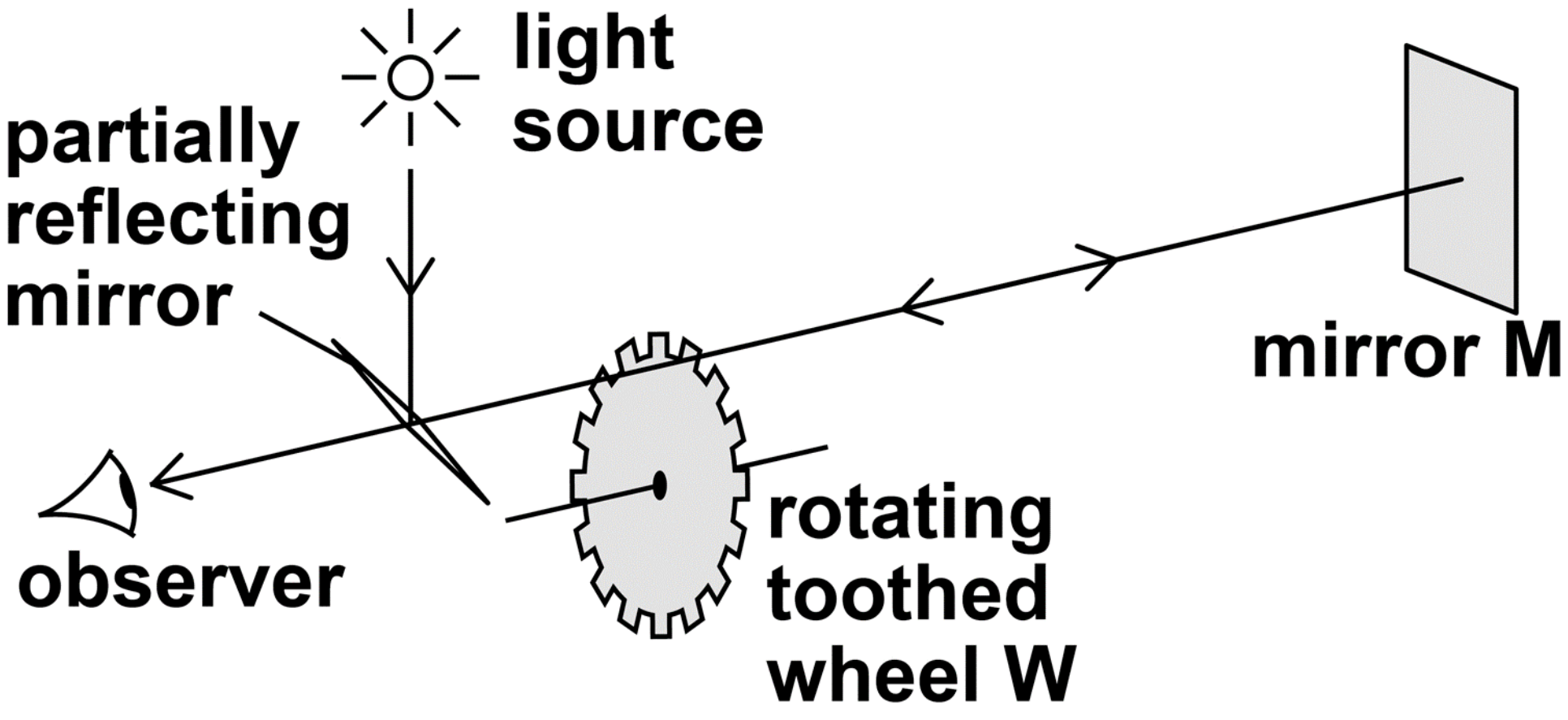
[Turn over]

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]

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

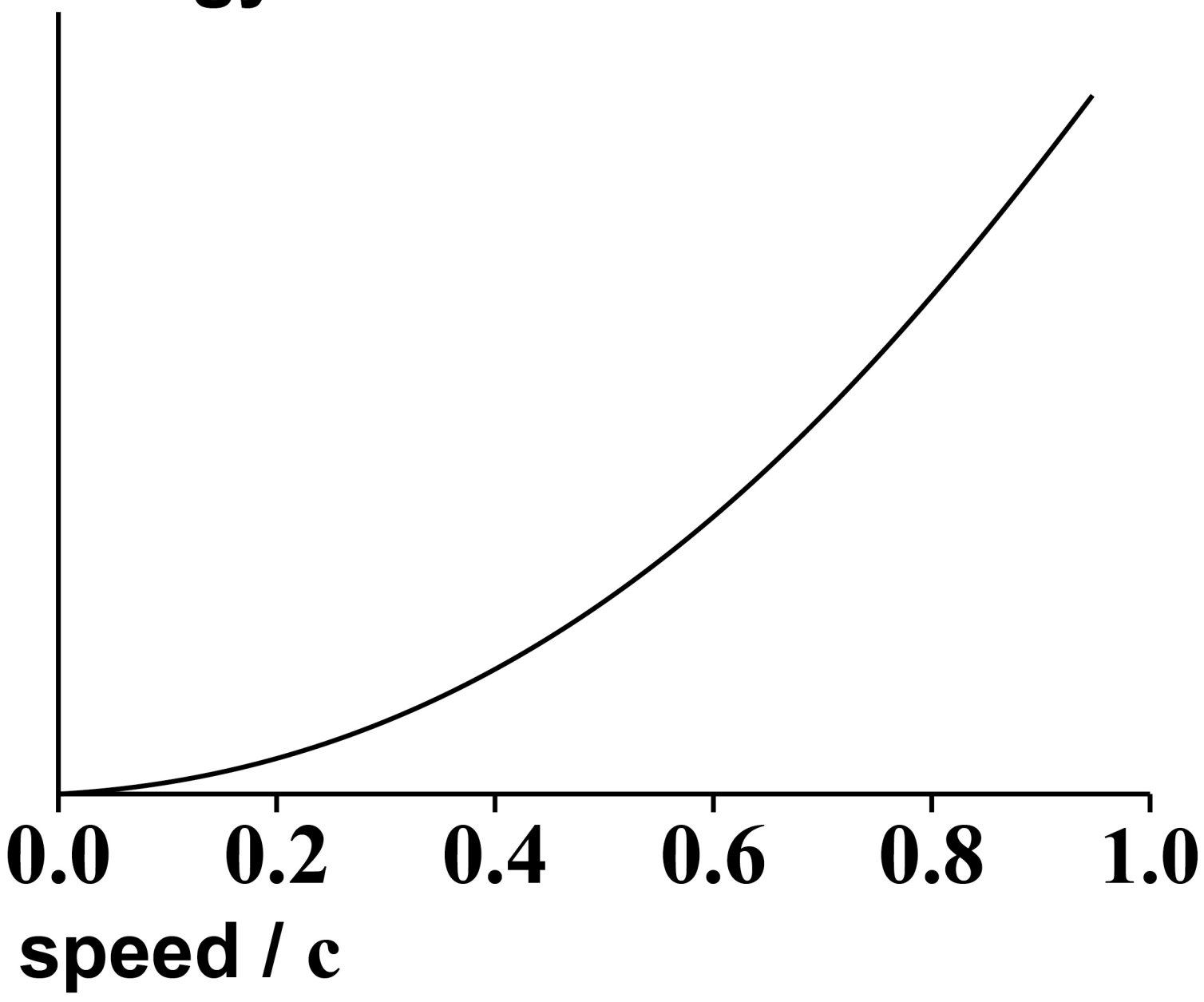
0 4 . 1

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

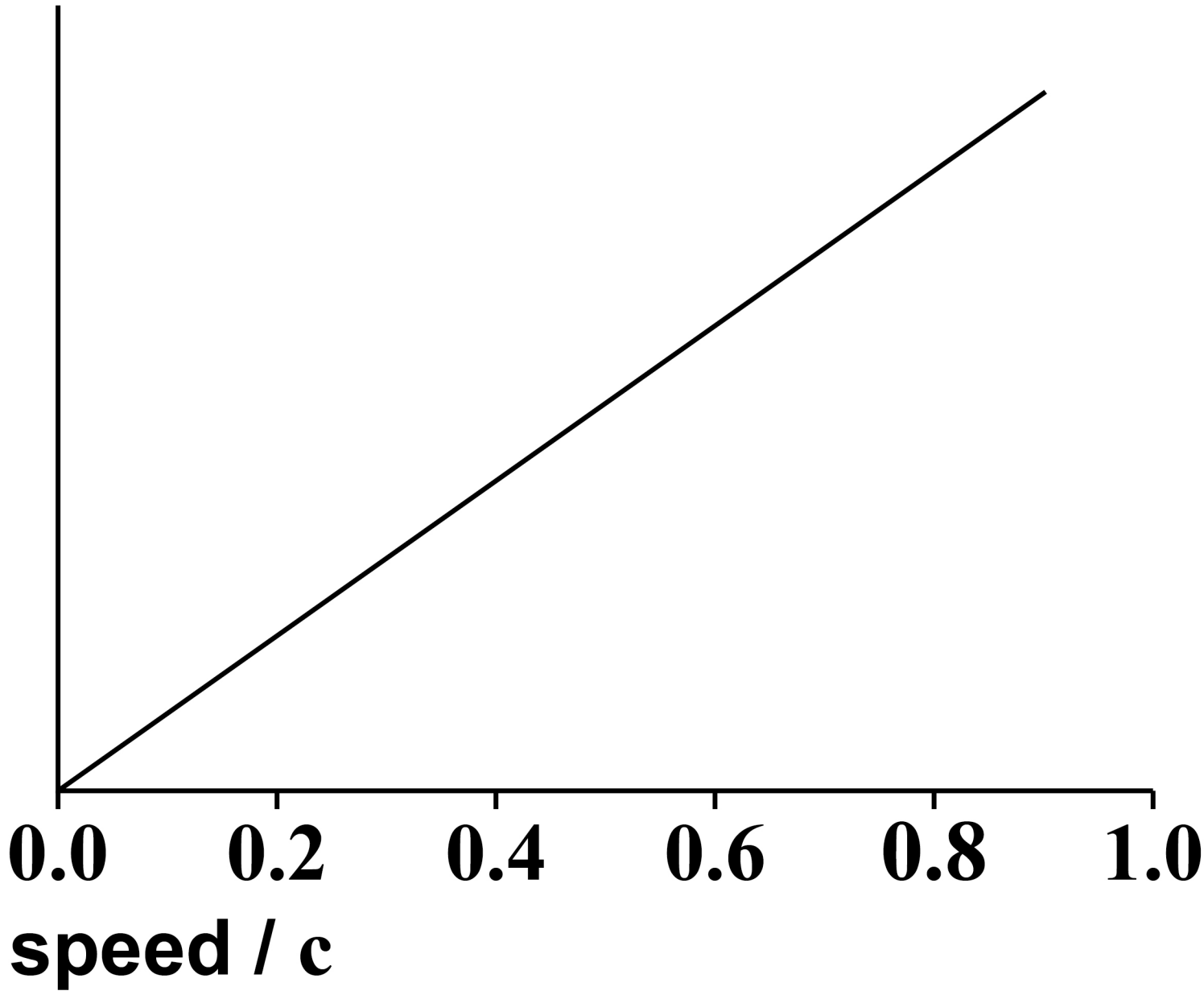
Which graph, on pages 34 to 37, shows the variation of kinetic energy with speed? [1 mark]

Tick (✓) ONE box.

☐ **A**



B kinetic energy



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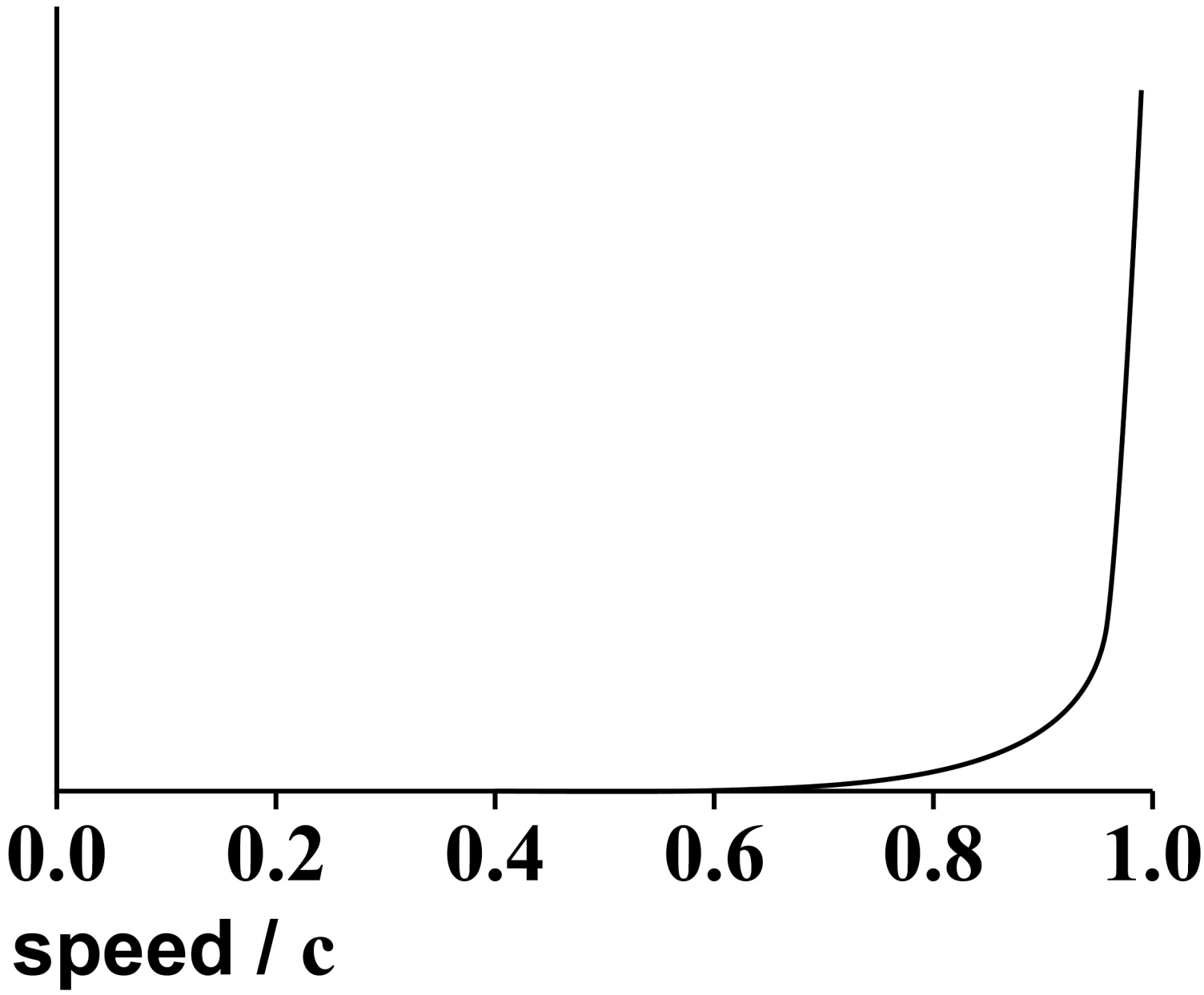
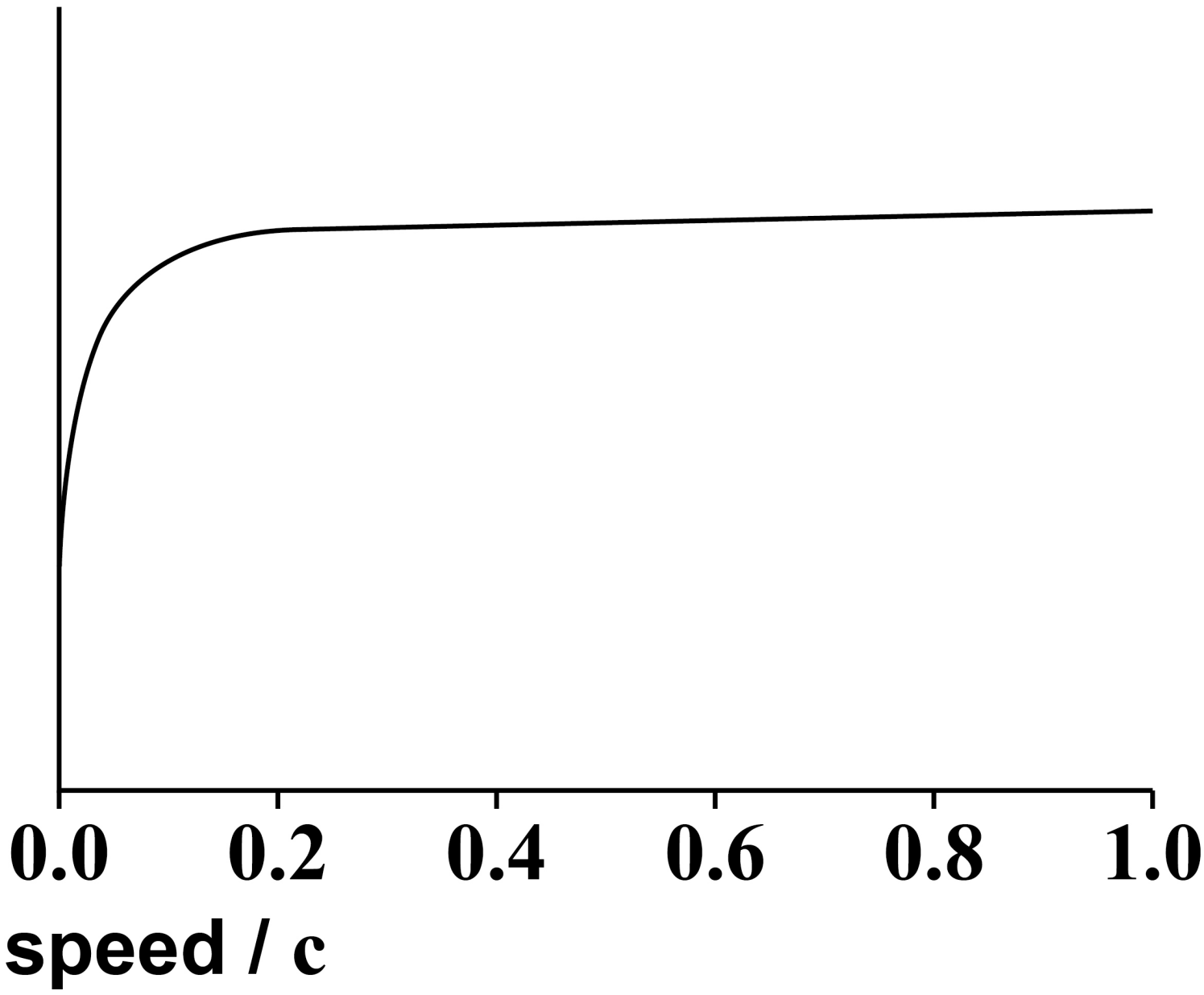
C kinetic energy



D kinetic energy



[Turn over]

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}**

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.

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For Examiner's Use	
Question	Mark
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