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

Friday 5 June 2020 Afternoon

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

[Turn over]

J U N 2 0 7 4 0 8 3 B D 0 1

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.**

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

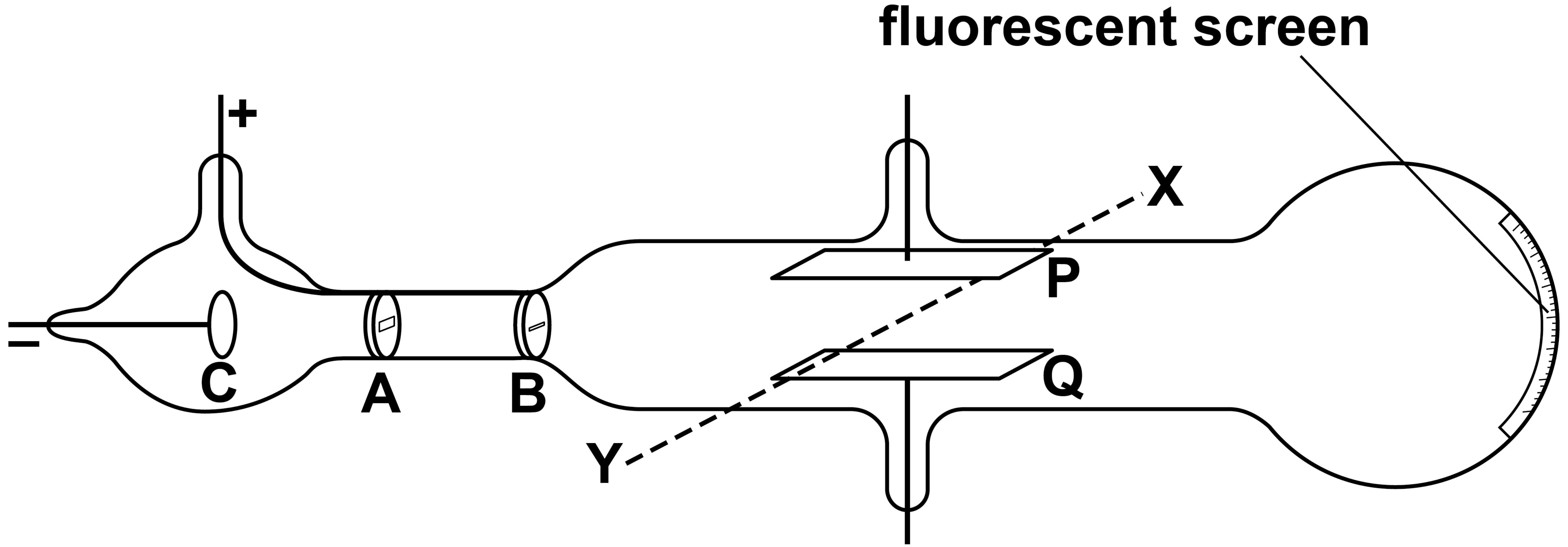
SECTION B

Answer ALL questions in this section.

0 1

FIGURE 1, on the opposite page, shows a diagram of a discharge tube used by JJ Thomson to investigate cathode rays.

FIGURE 1



The direction XY is horizontal and at right angles to the axis of the tube.

[Turn over]

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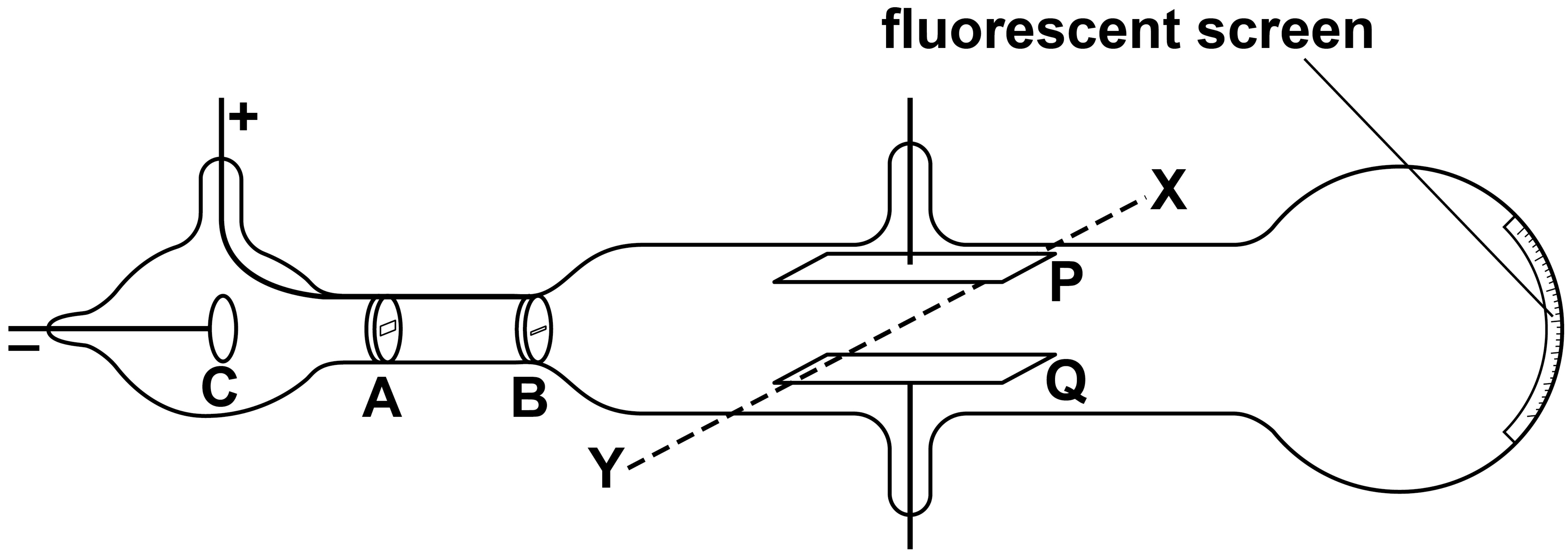
0 1 . 1

When correct connections are made to a high-voltage power supply, a cathode ray is produced. The cathode ray hits the centre of the fluorescent screen.

Describe how a cathode ray is produced in the discharge tube in FIGURE 1 on page 5. [2 marks]

REPEAT OF FIGURE 1



0 1 . 2

P and Q are metal plates that can be attached to a second power supply.

In an experiment, a potential difference (pd) is applied across P and Q so that P is positively charged and Q is negatively charged. This deflects the cathode ray.

Then a magnetic field is applied between the plates so that the cathode ray follows its original path to the centre of the screen.
What is the direction of the magnetic field?

Tick (✓) ONE box. [1 mark]

☐ from P to Q

☐ from Q to P

☐ from X to Y

☐ from Y to X

01.3

Changes are made to the apparatus so that the particles in the cathode ray travel with a greater speed as they pass between plates P and Q.

Explain how the cathode ray is restored to its original path by adjusting:

- only the electric field strength between P and Q
- only the magnetic flux density.

[3 marks]

electric field strength only ______________________________

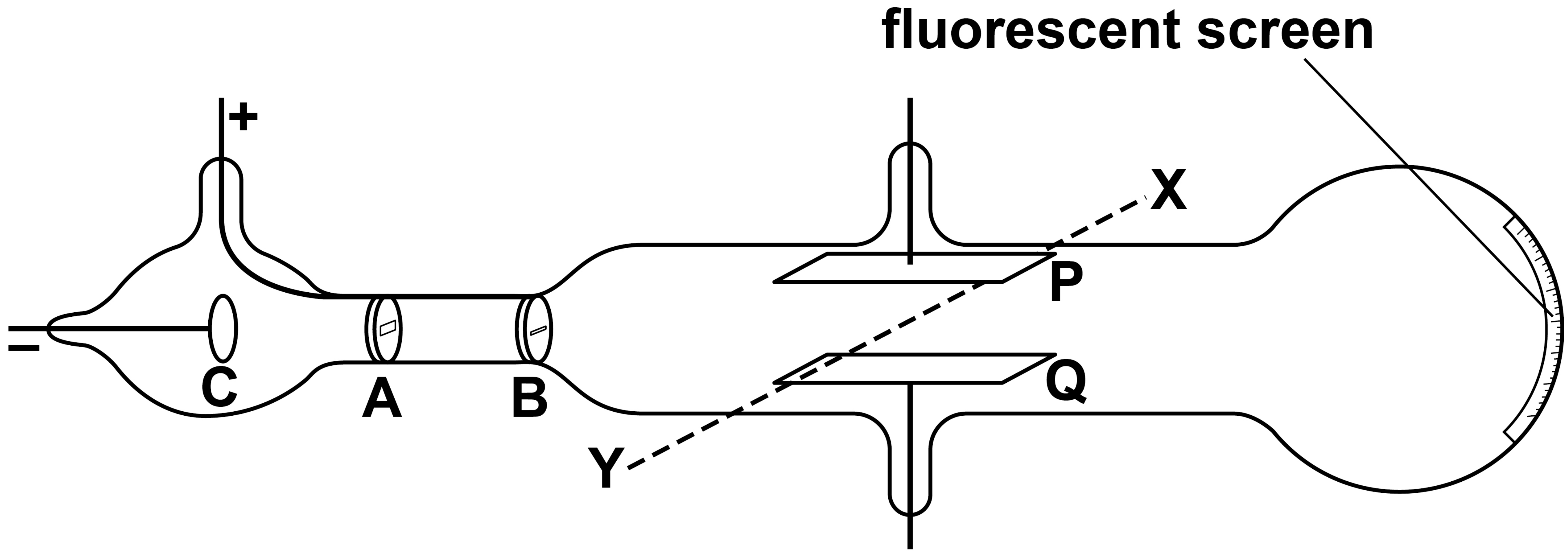
____

____

magnetic flux density only ____________________

[Turn over]

REPEAT OF FIGURE 1



0 1 . 4

Using the apparatus in FIGURE 1, Thomson determined the specific charge of the particles in the cathode rays. Thomson compared this result with the specific charge of the hydrogen ion.

Discuss the significance of Thomson's results for the particles in cathode rays, when compared with the specific charge of the hydrogen ion. [2 marks]

8

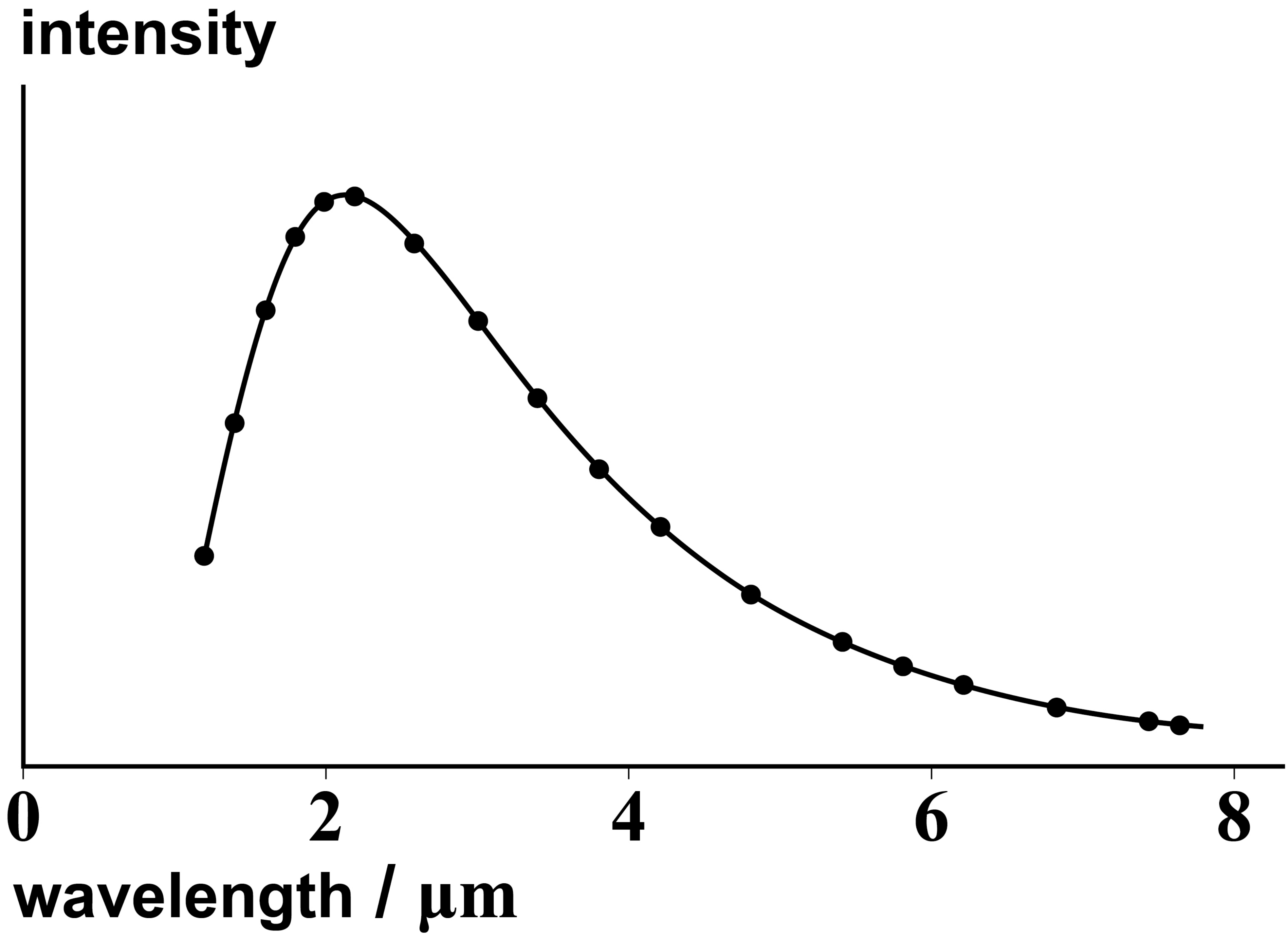
0 2

At the end of the 19th century new information was obtained about black-body radiation and the photoelectric effect. This information challenged classical physics theories.

In 1895, Wien and Lummer carried out experiments to measure black-body radiation accurately.

FIGURE 2, on the opposite page, shows a typical black-body radiation curve of the type obtained by Wien and Lummer.

FIGURE 2



[Turn over]

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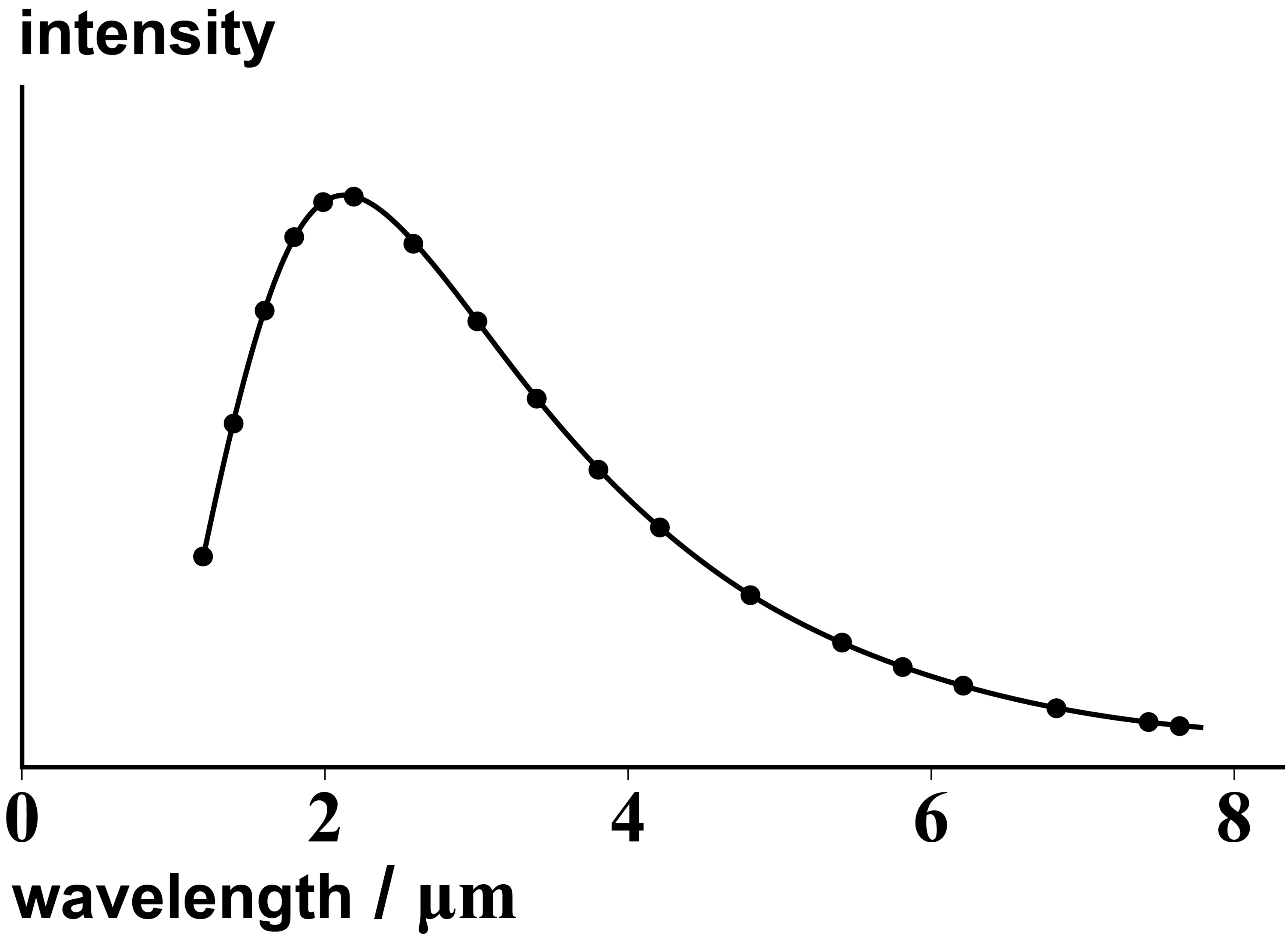
0 2 . 1

State what is meant by black-body radiation. [2 marks]

[Turn over]

REPEAT OF FIGURE 2



0 2 . 2

Describe how the predictions of classical theory compare with Wien and Lummer's experimental results.

Annotate FIGURE 2, on the opposite page, as part of your answer. [2 marks]

[Turn over]

0 2 . 3

In 1900 Max Planck suggested a solution to the problems of the classical theory.

Outline the main aspects of his suggestion. [2 marks]

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[Turn over]

0 2 . 4

Planck's suggestion was developed by Albert Einstein to explain the results of photoelectric effect experiments.

Discuss Einstein's explanation of photoelectricity and its significance in terms of the nature of electromagnetic radiation.

In your answer you should

- **describe TWO relevant observations made in photoelectric experiments**
- **explain the failure of classical physics to account for these observations**
- **include the main aspects of Einstein's theory and how he explained the observations.**

[6 marks]

12

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[Turn over]

03.1

The scanning tunnelling microscope (STM) uses a process called quantum tunnelling.

Explain what is meant by quantum tunnelling of an electron in an STM. You may include a diagram as part of your answer. [2 marks]

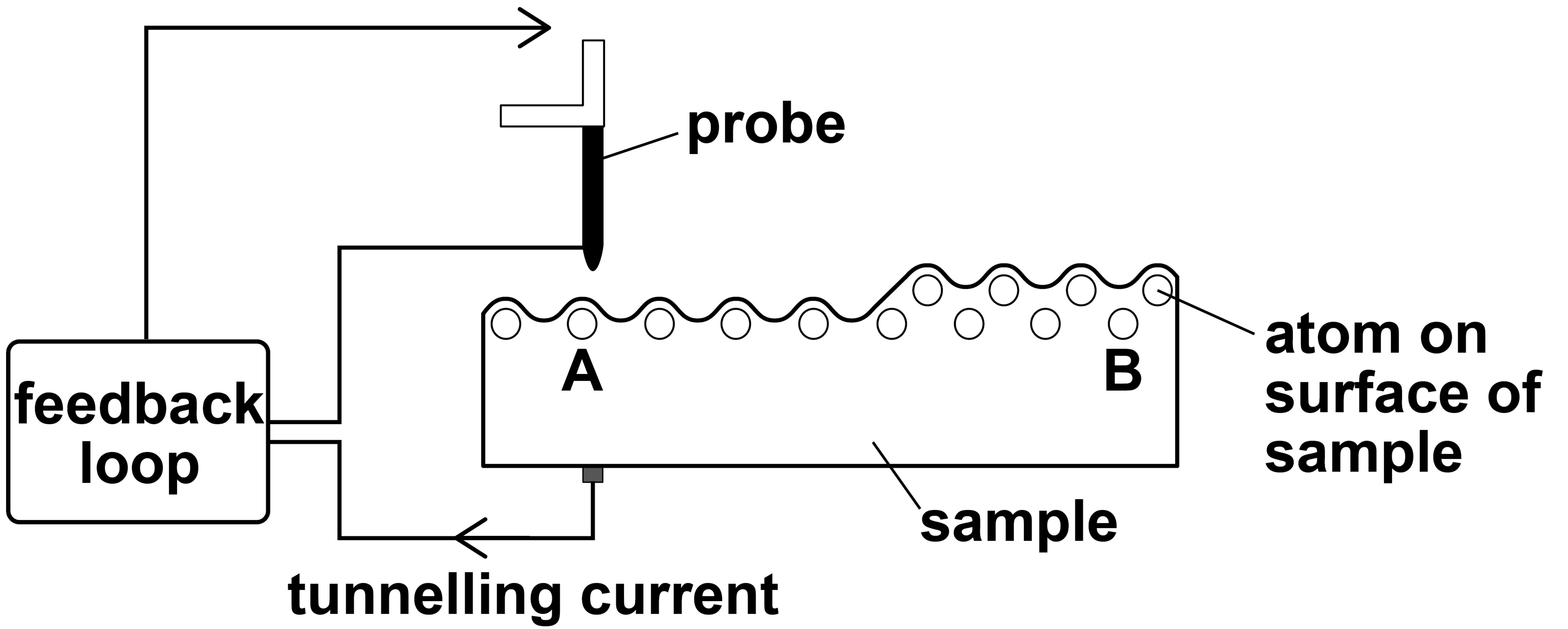
[Turn over]

0 3 . 2

An STM is used to map the positions of the atoms between points A and B on the surface of a sample.

FIGURE 3 shows some of the features of the operation of an STM.

FIGURE 3



The STM in FIGURE 3 is in constant-current mode.

Describe how the STM creates a map of the positions of one row of atoms on the surface of the sample from A to B.
[3 marks]

[Turn over]

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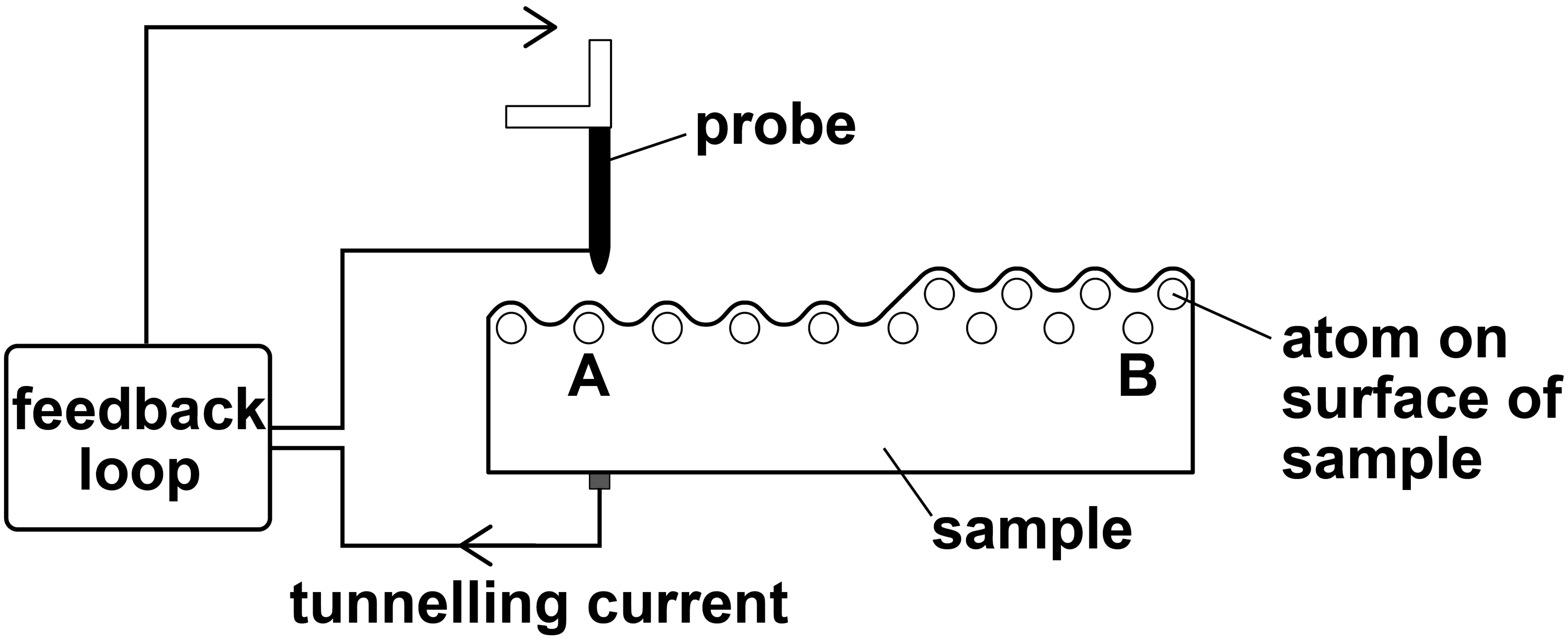
[Turn over]

REPEAT OF FIGURE 3



0 3 . 3

The smallest size of objects that the STM can resolve is similar to the de Broglie wavelength of the tunnelling electrons.

Deduce whether electrons with kinetic energies less than $1.5\ \mathrm{eV}$ are suitable to map the surface in FIGURE 3. [3 marks]

8

[Turn over]

0 4 . 1

A muon travels at a speed of $0.95c$ relative to an observer.

The muon travels a distance of 2.5×10^3 m between two points in the frame of reference of the observer.

Calculate the distance between these two points in the frame of reference of the muon. [2 marks]

distance = ______________________________ m

0 4 . 2

Measurements of muons created by cosmic rays can be used to demonstrate relativistic time dilation.

State the measurements made and the observation that provides evidence for relativistic time dilation. [2 marks]

[Turn over]

0 4 . 3

As the muons travel through the atmosphere, their speeds are reduced by interaction with the particles in the air.

Discuss, with reference to relativity, the effect that this reduction of speed has on the rate of detection of the muons on the surface of the Earth. [3 marks]

END OF QUESTIONS

7

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
1	
2	
3	
4	
TOTAL	