

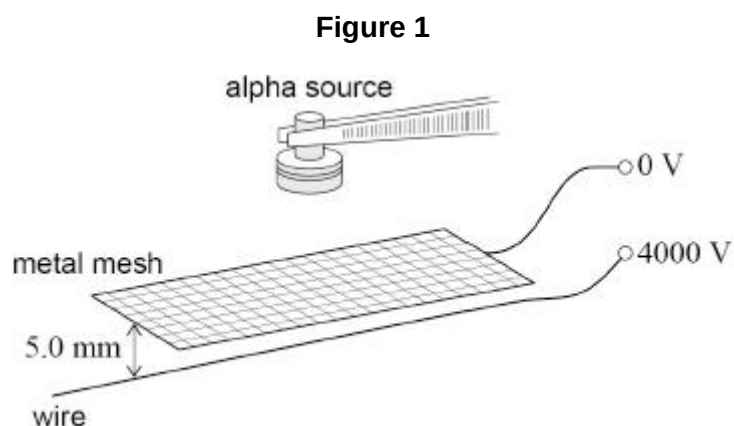
Name of the Student: _____

Max. Marks : 21 Marks

Time : 21 Minutes

Q1.

Figure 1 shows a spark detector used to detect alpha particles.



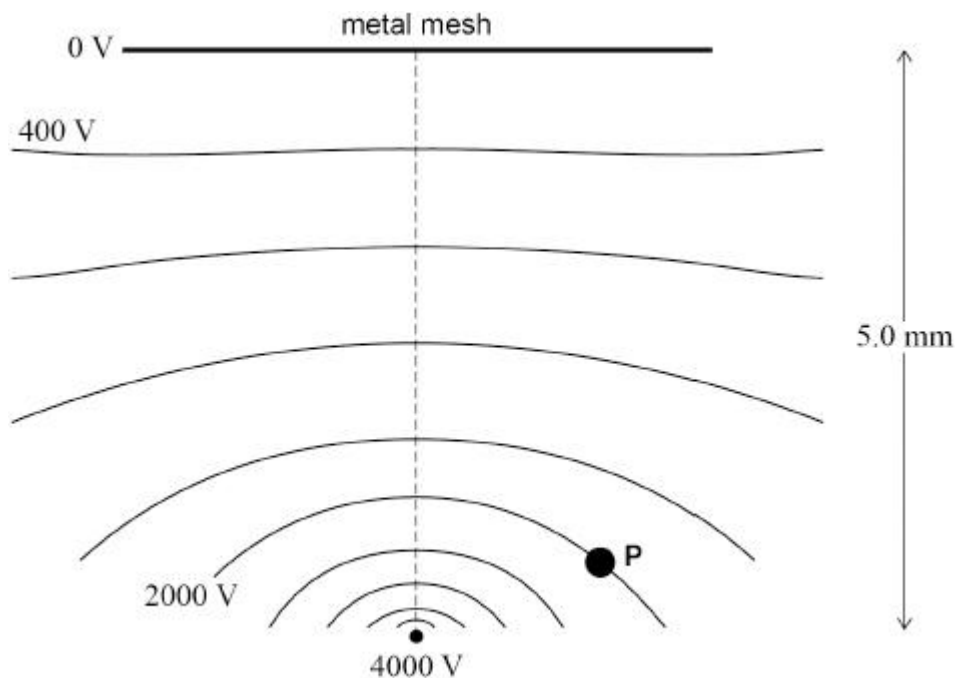
The detector consists of a metal mesh placed 5.0 mm above a wire.

A potential difference of 4000 V is applied between the mesh and the wire.

Molecules in the air between the mesh and the wire are ionised by an alpha particle and a spark is produced.

Figure 2 shows equipotentials between the mesh and the wire.

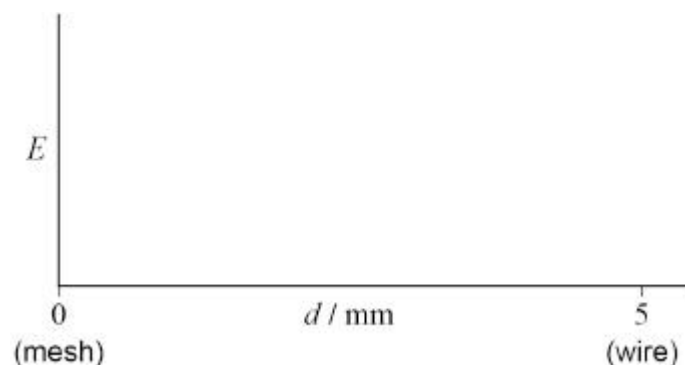
Figure 2



- (a) **Figure 2** shows a dashed line between the mesh and the wire.

Sketch on **Figure 3** a graph to show how the magnitude E of the electric field strength varies with the distance d from the mesh along this dashed line. No values are required on the E axis.

Figure 3



An alpha particle passes through the mesh.
The alpha particle ionises an argon atom at **P** on **Figure 2**, releasing one electron.
The electron and the argon ion have no kinetic energy at **P**.
The electron then travels to the wire and the argon ion travels to the mesh.

(2)

- (b) Calculate the ratio $\frac{\text{speed of electron when it reaches the wire}}{\text{speed of argon ion when it reaches the mesh}}$.

Assume that the air has no effect on the motion of the electron or on the motion of the argon ion.

$$\text{mass of argon ion} = 6.64 \times 10^{-26} \text{ kg}$$

ratio = _____

(2)

- (c) In practice, the air **does** affect the motion of the electron and the motion of the argon ion.

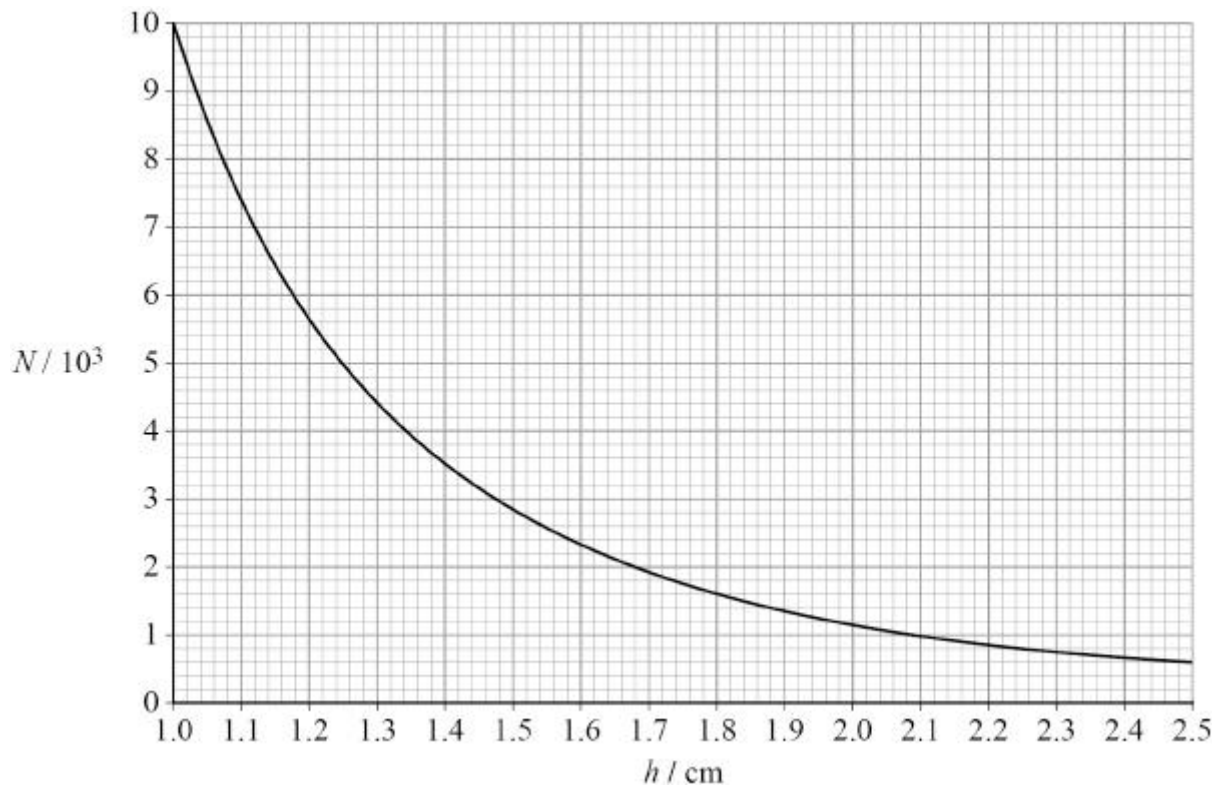
Suggest how the presence of air between the mesh and the wire changes the ratio in part (b).
No numerical detail is required.

(1)

- (d) The alpha source in **Figure 1** is moved to different heights h above the mesh.

Figure 4 shows how the number of sparks N produced in 10 minutes varies with h . No sparks are produced when the source is not present.

Figure 4



Student **A** suggests that the spark rate obeys an inverse-square law.

Student **B** suggests that the spark rate decreases exponentially with h .

Determine whether either student is correct.

Q2.

A stroboscope emits bright flashes of white light.
The duration of each flash and the frequency of the flashes can be varied.

The table below shows information about the stroboscope.

	Minimum	Maximum
Duration of each flash / μs	60	300
Frequency of flashes / Hz	1	150

The duration of each flash is T_1 .

The time from the start of a flash to the start of the next flash is T_2 .

The duty cycle of a stroboscope is defined as $\frac{T_1}{T_2}$.

(a) What is the maximum duty cycle of the stroboscope?

Tick ☒ **one** box.

6.0×10^{-5}

☐

3.0×10^{-4}

☐

9.0×10^{-3}

☐

4.5×10^{-2}

☐

(1)

(b) **Figure 1** shows images produced in an experiment in which a bouncing ball is illuminated by a stroboscope.
The stroboscope flashes at a constant frequency.

Figure 1

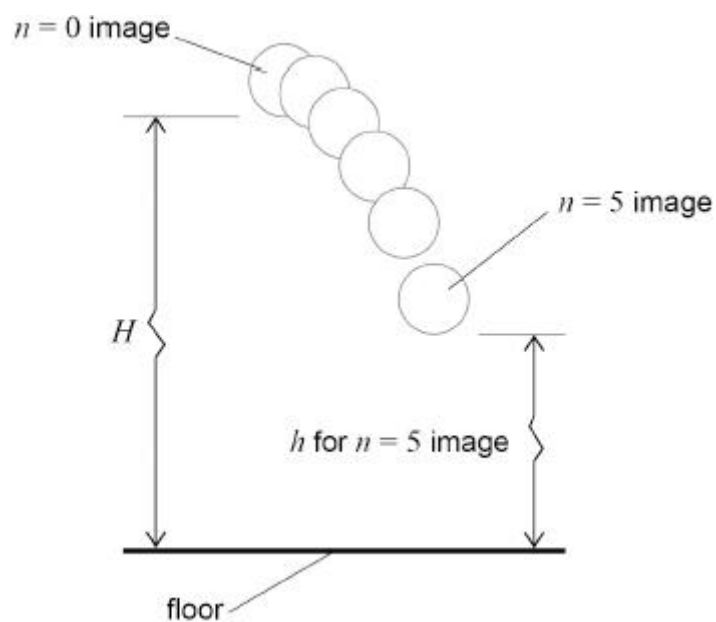


Suggest why T_1 must be very short for this experiment.

(1)

Figure 2 shows the first six images starting with $n = 0$, where n is the image number.

Figure 2



The images are used to determine:

H , the vertical distance from the bottom of the ball to the floor when $n = 0$

h , the vertical distance from the bottom of the ball to the floor for each non-zero value of n .

The $n = N$ image is produced at the instant that the ball hits the floor for the first time. For n between 0 and N it can be shown that

$$H - h = \frac{u_0 n}{f} + \frac{g}{2} \left(\frac{n}{f} \right)^2$$

where

u_0 is the vertical velocity of the ball when $n = 0$

g is the acceleration due to gravity

f is the frequency of the flashes.

- (c) In order to find g , a graph is plotted with values of $\frac{H-h}{n}$ on the y-axis.

Suggest what is plotted on the x-axis.

Go on to explain how g is determined from this graph.

The following data are recorded.

$$H = 1550 \text{ mm}$$

$$f = 31.0 \text{ Hz}$$

The graphical analysis of data from **Figure 1** gives g as 9.79 m s^{-2} .

(3)

- (d) Determine u_0 .

$$u_0 = \text{_____} \text{ m s}^{-1}$$

(3)

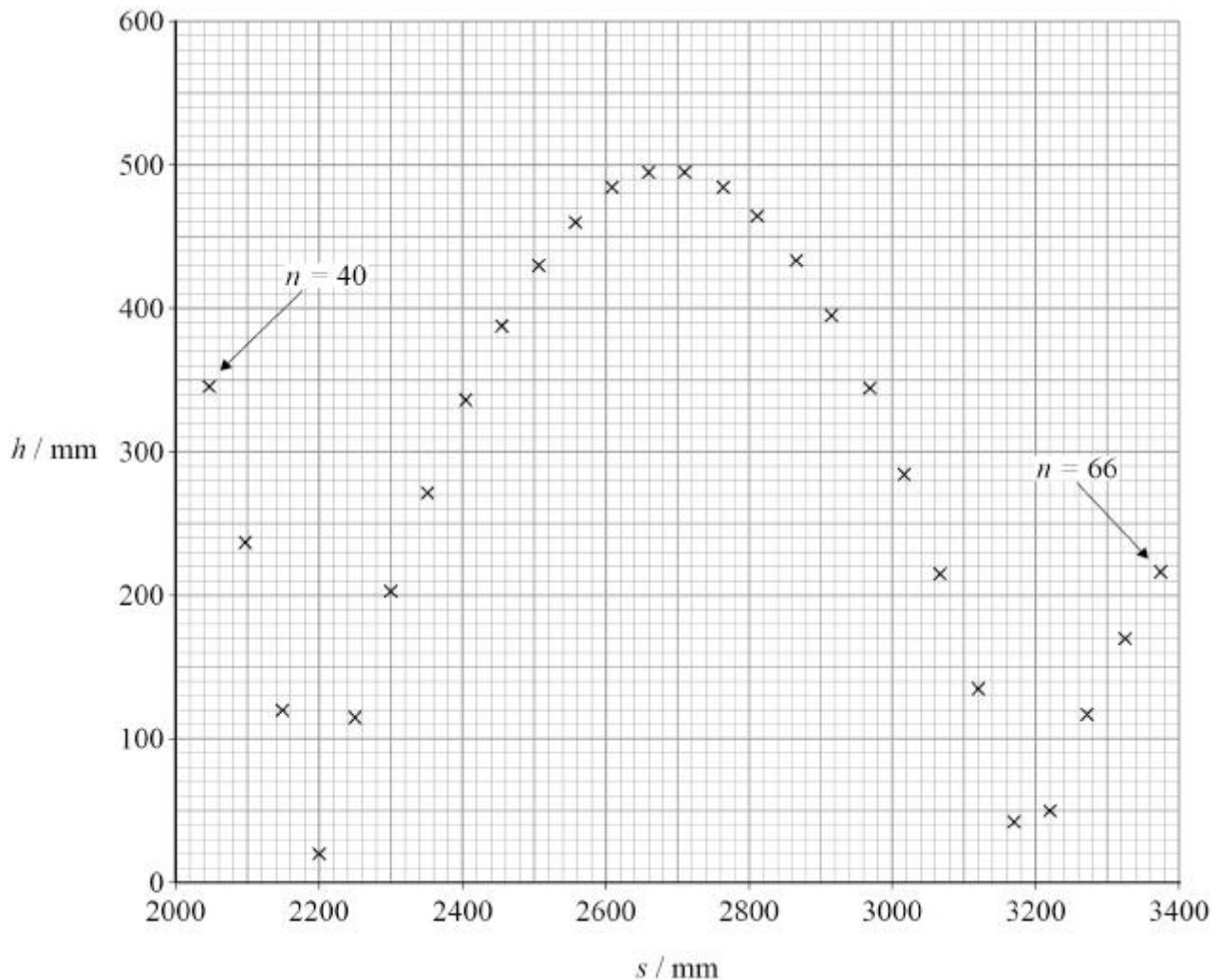
Figure 3 shows positions of the bottom of the ball for $n = 40$ to $n = 66$

In this range of positions, the ball makes contact with the floor for the second and third times.

Values of h , the vertical distance from the bottom of the ball to the floor, are plotted on the y -axis.

Values of s , the horizontal displacement from a point on the floor below the centre of the $n = 0$ image, are plotted on the x -axis.

Figure 3



- (e) Determine, in mm s^{-1} , the horizontal velocity of the ball between the second and third contacts of the ball with the floor.

horizontal velocity = _____ mm s^{-1}

(2)

- (f) Determine the time between the second and third contacts.

Annotate **Figure 3** to show your method.

time = _____ s
(3)
(Total 13 marks)