1. Nov/2023/Paper_9702/41/No.6

(a) Define magnetic flux density.

....

....

....

.... [2]

(b) Electrons are moving in a vacuum with speed $1.7 \times 10^7\,\text{m s}^{-1}$. The electrons enter a uniform magnetic field of flux density 4.8 mT. Fig. 6.1 shows the path of the electrons.

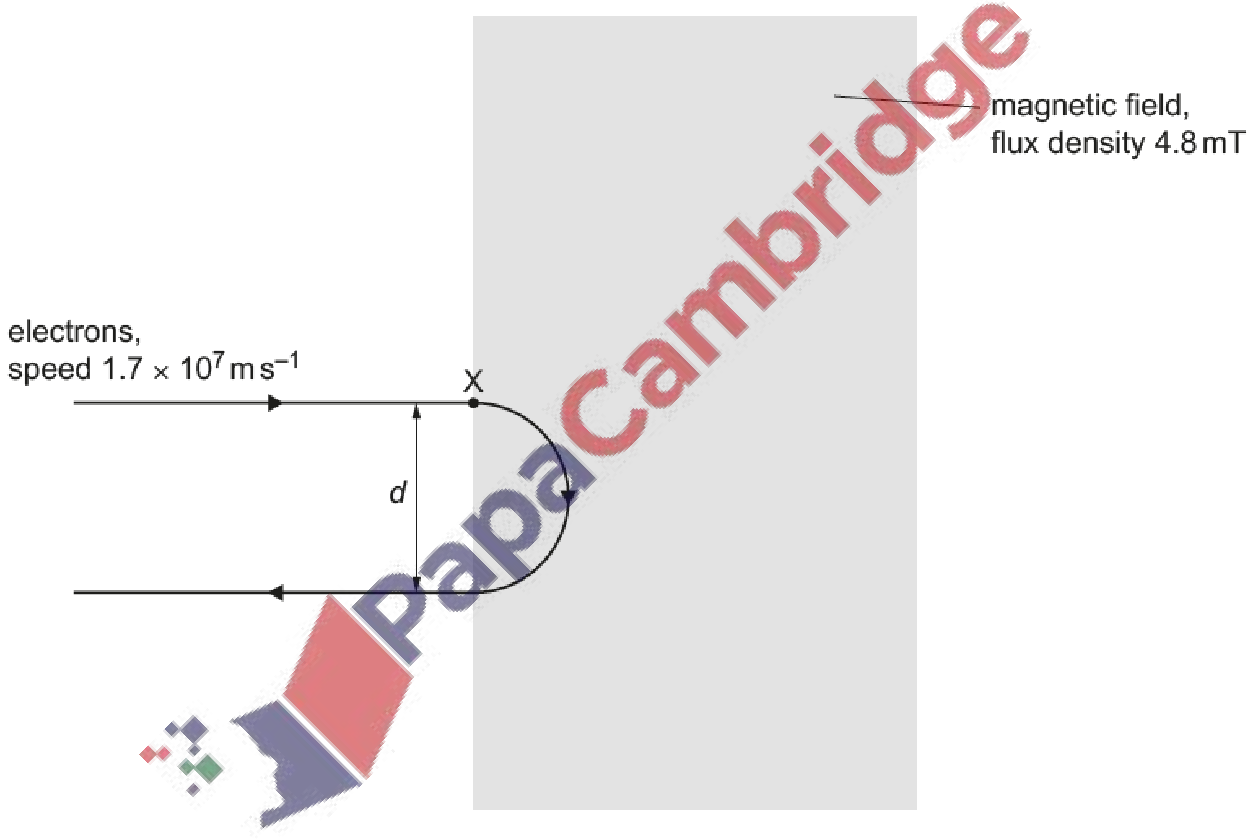

Fig. 6.1

The path of the electrons remains in the plane of the page.

(i) State the direction of the magnetic field.

....

.... [1]

(ii) Show that the magnitude of the force exerted on each electron by the magnetic field is 1.3×10^{-14} N.

[2]

(iii) On Fig. 6.1, draw an arrow to indicate the direction of the centripetal acceleration of the electron where it enters the magnetic field at point X. [1]

(iv) Use the information in **(b)(ii)** to calculate the distance *d* between the path of the electrons entering the magnetic field and the path of the electrons leaving it.

d = ... m [3]

(c) The electrons in **(b)** are replaced with positrons that are moving with speed 3.4×10^{7} m s^{-1} along the same initial path as the electrons.
The positrons enter the magnetic field at point X on Fig. 6.1.

On Fig. 6.1, draw a line to show the path of the positrons through the magnetic field. [3]

[Total: 12]

2. Nov/2023/Paper_9702/42/No.7

(a) A Hall probe containing a thin slice of semiconducting material is placed in a uniform magnetic field of flux density B. The largest faces of the slice are perpendicular to the magnetic field, as shown in Fig. 7.1.

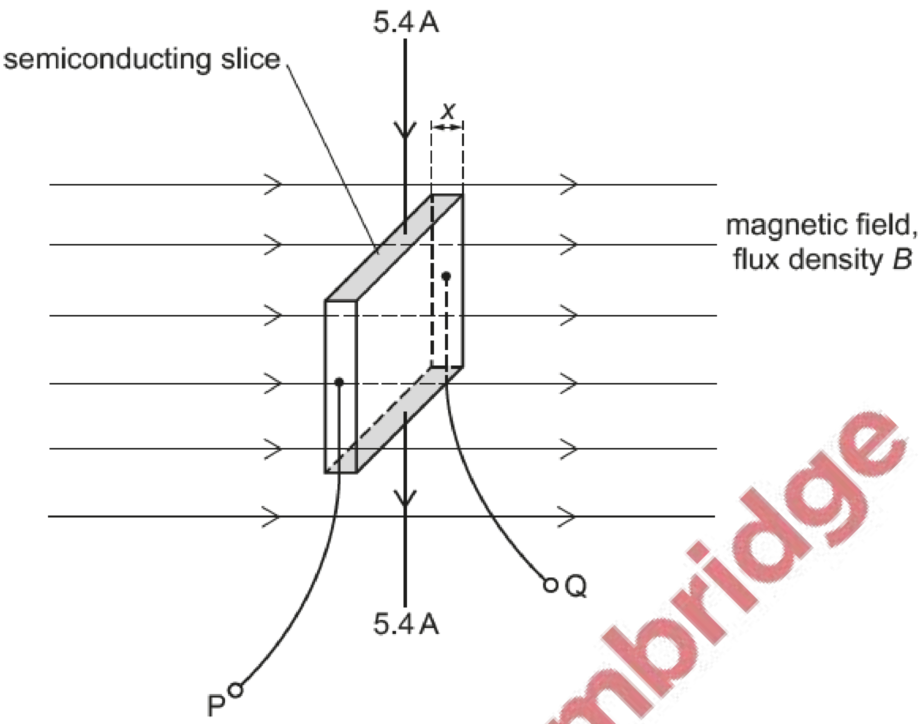

Fig. 7.1

The thickness x of the slice is 1.8 mm. The number density of charge carriers in the semiconducting material is $1.5 \times 10^{16}\ \text{m}^{-3}$.

A constant current of 5.4 A is passed through the slice between the shaded faces.

The Hall voltage V_H that is developed between the terminals PQ is recorded.

Fig. 7.2 shows the variation with time t of B.

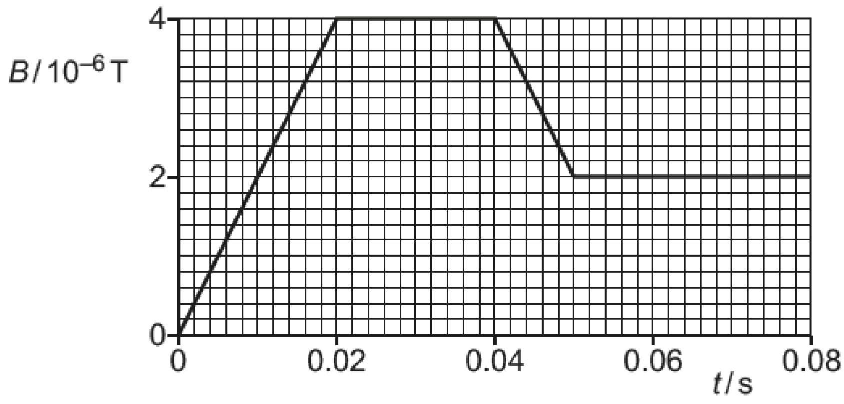

Fig. 7.2

(i) Show that, when B is equal to 4.0×10^{-6} T, the magnitude of V_H is 5.0 V.

[1]

(ii) On Fig. 7.3, sketch the variation of V_H with t between $t = 0$ and $t = 0.080$ s.

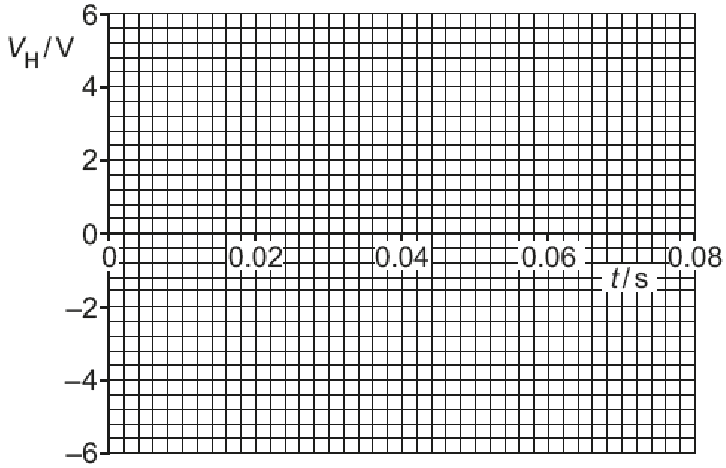

Fig. 7.3

[3]

(b) The Hall probe in **(a)** is replaced with a small flat coil that has 3000 turns. The cross-sectional area of the coil is 3.4×10^{-4} m^2.
The plane of the coil is perpendicular to the magnetic field. The electromotive force (e.m.f.) E induced between the terminals of the coil is recorded as B varies as shown in Fig. 7.2.

(i) Show that the magnitude of E at time $t = 0.010$ s is 2.0×10^{-4} V.

[3]

(ii) On Fig. 7.4, sketch the variation of E with t between $t = 0$ and $t = 0.080$ s.

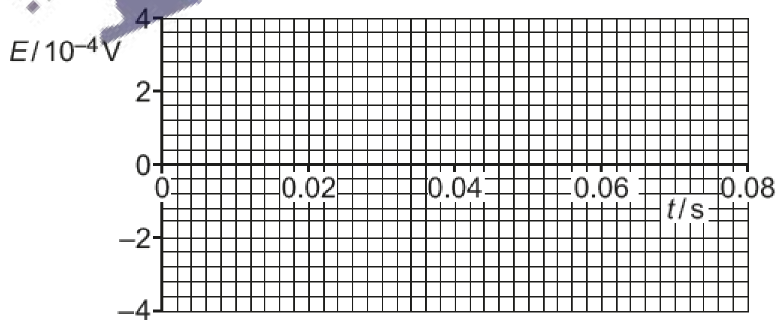

Fig. 7.4

[4]

[Total: 11]

3. June/2023/Paper_9702/41/No.6

(a) State what is meant by a magnetic field.

....

....

.... [2]

(b) A long, straight wire P carries a current into the page, as shown in Fig. 6.1.

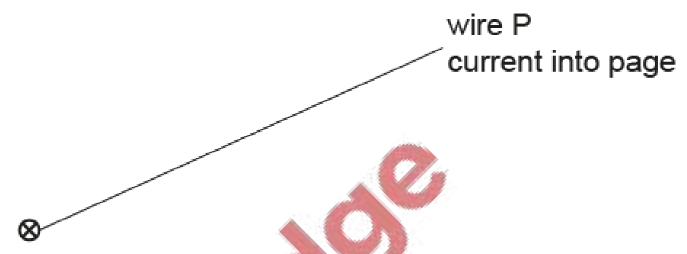

Fig. 6.1

On Fig. 6.1, draw four field lines to represent the magnetic field around wire P due to the current in the wire. [3]

(c) A second long, straight wire Q, carrying a current of 5.0 A out of the page, is placed parallel to wire P, as shown in Fig. 6.2.

Fig. 6.2

The flux density of the magnetic field at wire Q due to the current in wire P is 2.6 mT.

(i) Calculate the magnetic force per unit length exerted on wire Q by wire P.

force per unit length = ... $N m^{-1}$ [2]

(ii) State the direction of the force exerted on wire Q by wire P.

.... [1]

(iii) The flux density of the magnetic field at wire P due to the current in wire Q is 1.5 mT.

Determine the magnitude of the current in wire P. Explain your reasoning.

current = ... A [2]

[Total: 10]

4. March/2023/Paper_9702/42/No.6

(a) A Hall probe is placed in a magnetic field. The Hall voltage is zero. The Hall probe is rotated to a new position in the magnetic field. The Hall voltage is now maximum.

Explain these observations.

....

....

.... [2]

(b) The formula for calculating the Hall voltage V_H as measured by a Hall probe is

$$V_H = \frac{BI}{ntq}.$$

Table 6.1 shows the value of *n* for two materials.

Table 6.1

material	n / m^{-3}
silicon	9.65×10^{15}
copper	8.49×10^{28}

(i) State the meaning of *n*.

....

.... [1]

(ii) Explain why a Hall probe is made from silicon rather than copper.

....

.... [1]

(c) A Hall probe gives a maximum reading of 24 mV when placed in a uniform magnetic field of flux density 32 mT.

The same Hall probe is then placed in a magnetic field of fixed direction and varying flux density. The Hall probe is in a fixed position so that the angle between the Hall probe and the magnetic field is the same as when the Hall voltage was 24 mV.

The variation of the reading V_H on the Hall probe with time t from time t = 0 to time t = 8.6 s is shown in Fig. 6.1.

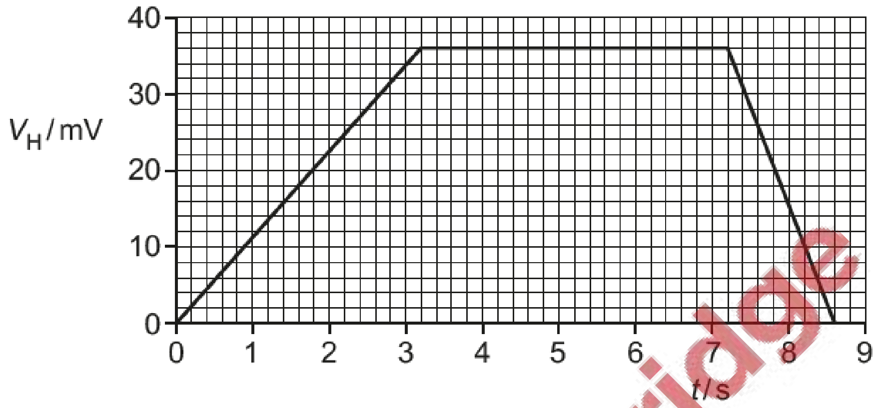

Fig. 6.1

A coil with 780 turns and a diameter of 3.6 cm is placed in this varying magnetic field. The plane of the coil is perpendicular to the field lines.

Calculate the magnitude of the maximum electromotive force (e.m.f.) induced in the coil in the time between t = 0 and t = 8.6 s.

e.m.f. = ... V [4]

[Total: 8]