6 **(a)** A slice of a conducting material has its face QRLK normal to a uniform magnetic field of flux density B, as illustrated in Fig. 6.1.

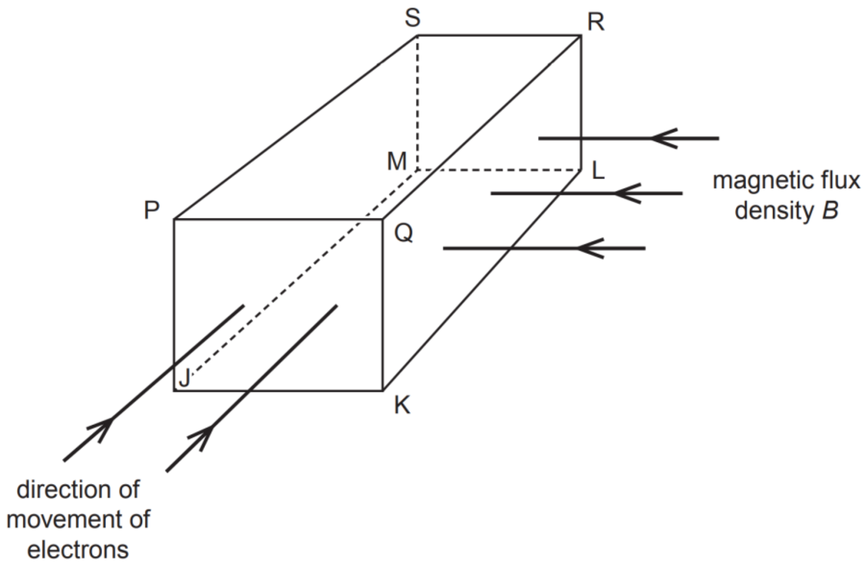

Fig. 6.1

Electrons enter the slice travelling perpendicular to face PQKJ.

(i) For the free electrons moving in the slice:

1. identify the faces, using the letters on Fig. 6.1, between which a potential difference is developed. State its polarity.

face: ………………, polarity: ………………

and face: ………………, polarity: ……………… [2]

2. Explain your answers above.

………………………………………………………………………………………

……………………………………………………………………………………… [1]

(ii) Considering the forces acting on the electrons, explain why the potential difference between the faces identified reaches a maximum value.

………………………………………………………………………………………

……………………………………..…………………………………..……………...

……………………………………..…………………………………..………….. [2]

(iii) The number of free electrons per unit volume n in the slice of conducting material is 1.3×10^{29} m^{-3}.
The thickness PQ of the slice is 0.10 mm.
The magnetic flux density B is 4.6×10^{-3} T.
The current I is 6.3×10^{-4} A.

Using $I = nAve$, where A is the cross-sectional area PQJK, and v is the drift velocity of the electron,

calculate the maximum potential difference across the slice.

maximum potential difference = ……………………….. V [3]

(b) A thin copper sheet X is supported on a rigid rod so that it hangs between the poles of a magnet as shown in Fig. 6.2.

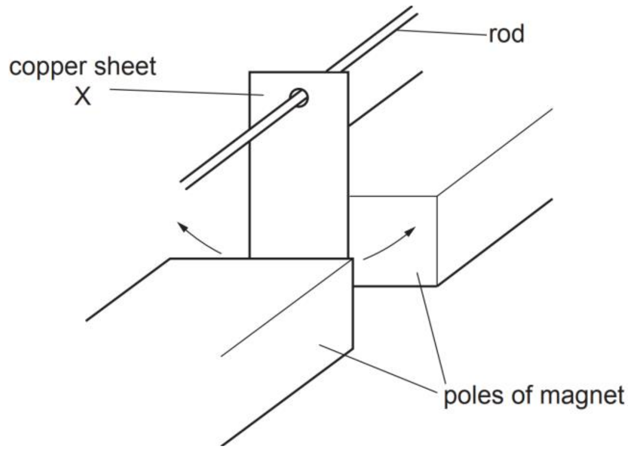

Fig. 6.2

Sheet X is displaced to one side and then released so that it oscillates. A motion sensor is used to record the displacement of X.

A second thin copper sheet Y replaces sheet X. Sheet Y has the same overall dimensions as X but is cut into the shape shown in Fig. 6.3.

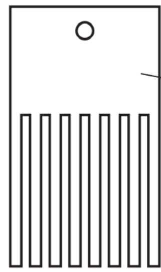

Fig. 6.3

The motion sensor is again used to record the displacement.

The graph in Fig. 6.4 shows the variation with time t of the displacement s of each copper sheet.

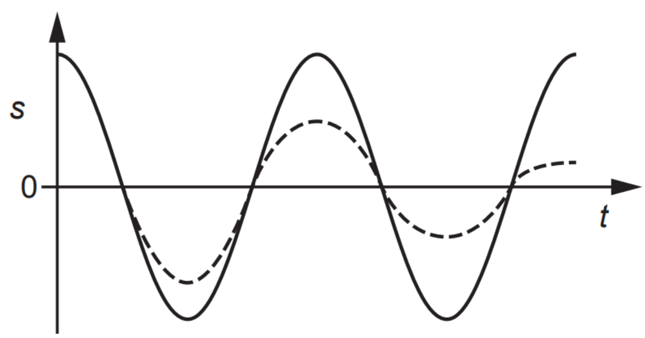

Fig. 6.4

(i) State the name of the phenomenon illustrated by the dashed line.

.... [1]

(ii) Deduce which copper sheet is represented by the dashed line. Explain your answer using the principles of electromagnetic induction.

....

....

....

....

....

....

.... [4]

(c) Fig. 6.5 shows a simple alternating current generator, consisting of a coil of 500 turns rotating at a constant frequency of 50 Hz in a uniform magnetic flux density 5.0×10^{-2} T. The coil has an area of 2.5×10^{-2} m^2.

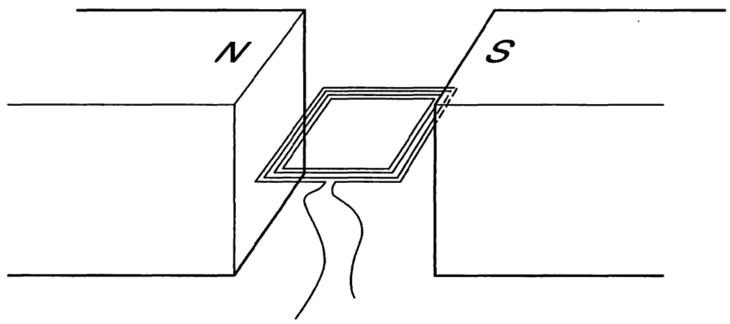

Fig. 6.5

(i) Show that the root-mean-square electromotive force (emf) induced across the coil is 140 V.

[2]

(ii) The output of the generator is connected to the input of a transformer as shown in Fig 6.6. The transformer has 2000 turns in the primary coil and 50 turns on its secondary coil.

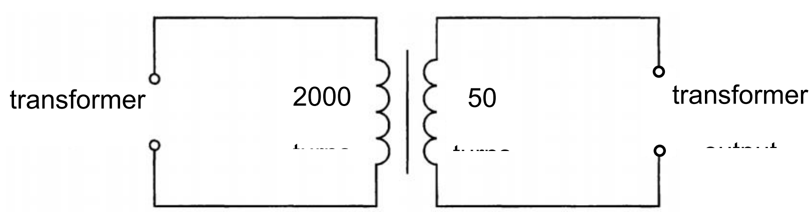

Fig. 6.6

Calculate the maximum voltage across the secondary coil.

maximum voltage across secondary coil = …………………….. V [1]

(iii) The transformer output is connected to four identical diodes W, X, Y and Z which do not conduct in the reverse direction. In the forward direction, each diode conducts when the potential difference across the diode is greater than 0.70 V. This setup, shown in Fig. 6.7, is used to recharge a nickel-cadmium cell with an emf of 1.2 V.

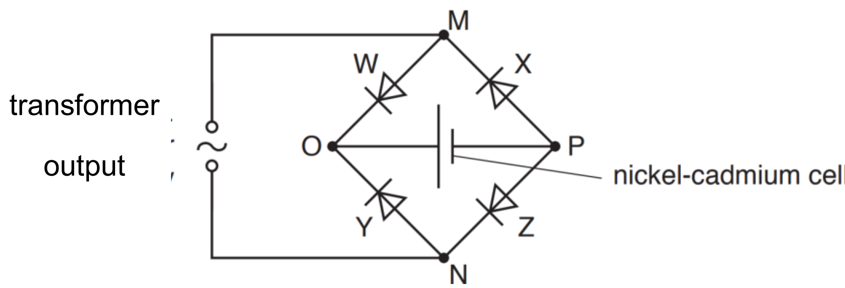

Fig. 6.7

Fig. 6.8 shows how the emf of the transformer output and the current in the cell vary with time. The current in the cell during each half-cycle of the transformer output is always in the same direction.

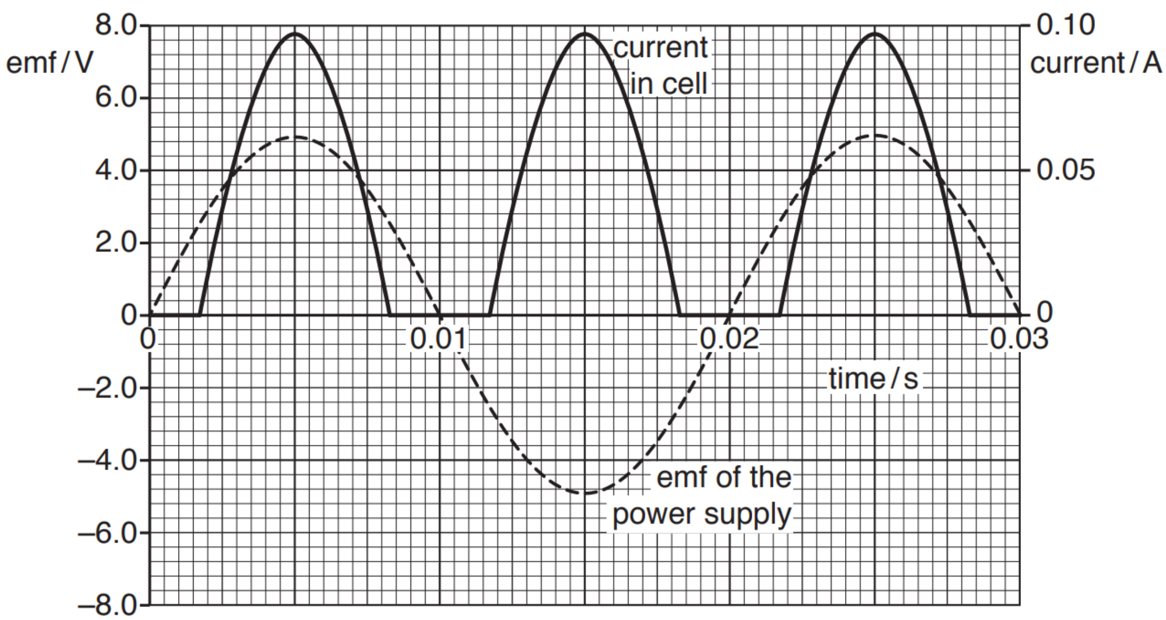

Fig. 6.8

1. At certain times, there is no current in the cell, even though the emf of the power supply is greater than zero. Suggest why, at these times, there is no current in the cell.

……………………………………………………………………………………….

…………………………………………………………………………………….. [2]

2. Use Fig. 6.8 to estimate the quantity of charge that flows in the cell in a 0.010 s period of time.

charge = …………………………….. C [2]

End of Paper