H2 Physics Revision Topic : Electromagnetic Induction

Structured Questions Name: ______________________

1 **(a)** A coil of wire is situated in a uniform magnetic field of flux density *B*.
The coil has diameter 3.6 cm and consists of 350 turns of wire, as illustrated in Fig. 4.1.

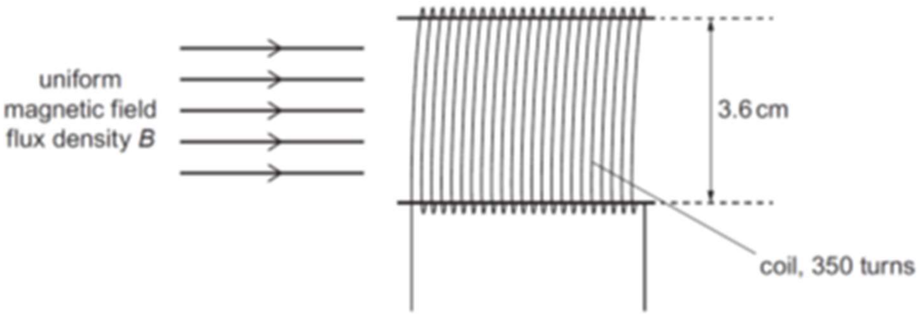

Fig. 4.1

The variation with time *t* of *B* is shown in Fig. 4.2.

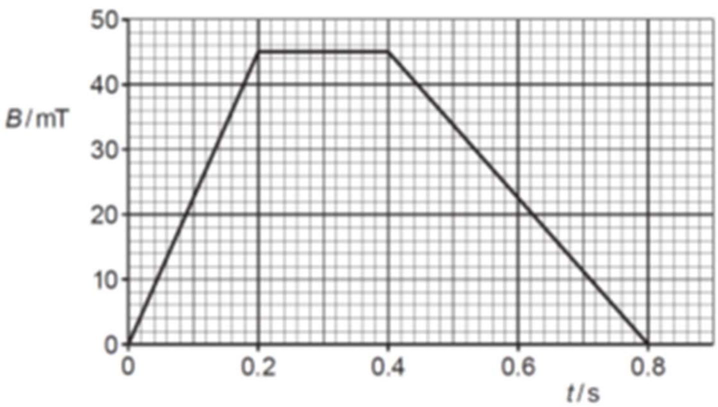

Fig. 4.2

(i) Show that, for the time $t = 0$ to time $t = 0.20$ s, the electromotive force (e.m.f.) induced in the coil is 0.080 V.

[2]

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(ii) On the axes of Fig. 4.3, show the variation with time *t* of the induced e.m.f. *E* for time *t* = 0 to time *t* = 0.80 s.

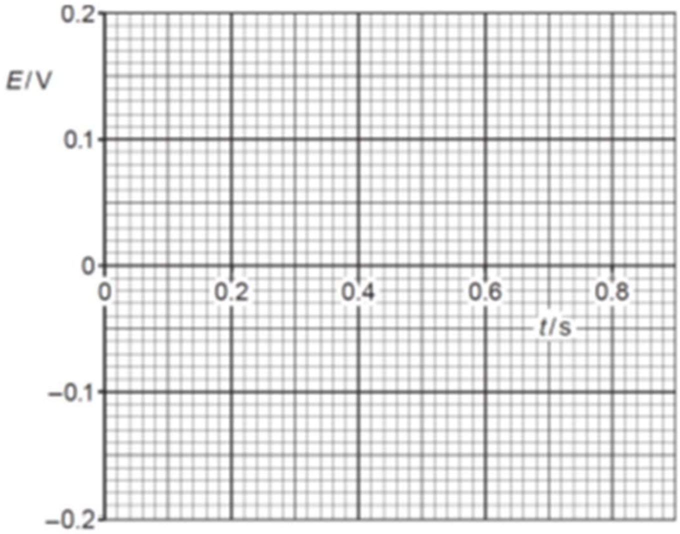

Fig. 4.3

[4]

1 **(b)** A bar magnet is held a small distance above the surface of an aluminium disc by means of a rod, as illustrated in Fig. 4.4.

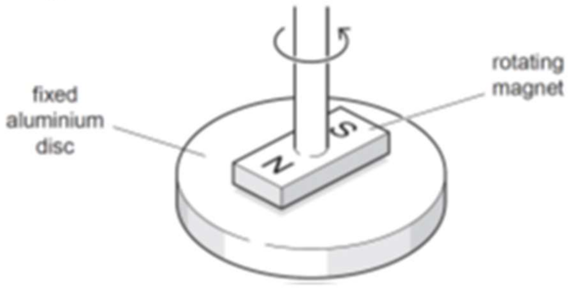

Fig. 4.4

The aluminium disc is supported horizontally and held stationary.
The magnet is rotated about a vertical axis at constant speed.

Use Faraday's law to explain why there is a force acting on the aluminium disc.

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.... [4]

[Total: 10]

2 A magnet rotates inside a shaped soft iron core. A coil is wrapped around the iron core as shown in Fig. 7.1. The coil is connected to an oscilloscope.

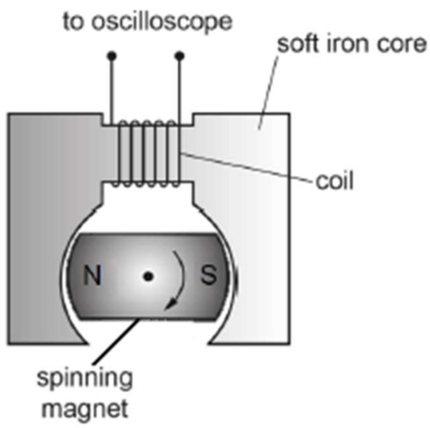

Fig. 7.1

2 The spinning magnet induces an e.m.f. in the coil.

(a) On Fig. 7.2, sketch a graph of the variation of the e.m.f. induced in the coil against time. The variation of the induced magnetic flux linkage in the coil is shown as a dotted line. [1]

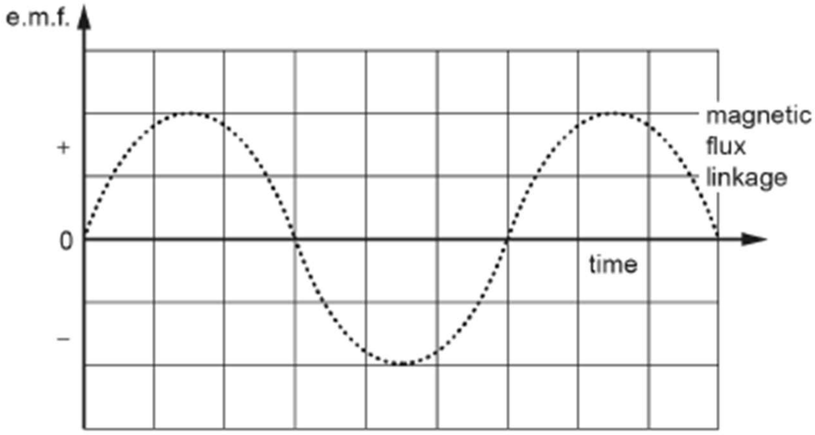

Fig. 7.2

(b) By considering the orientation of the magnet as it spins, explain the variation of the magnetic flux linkage in the coil with time.

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....[2]

(c) At a certain time t_1 the orientation of the spinning magnet is momentarily as shown in Fig. 7.1. Mark the time t_1 on the time axis of Fig. 7.2. [1]

(d) The coil shown in Fig. 7.1 has 150 turns. The maximum induced e.m.f. V_0 across the coil is 1.2 V when the magnet is rotating at 24 revolutions per second.

Calculate the maximum magnetic flux through the coil.

maximum magnetic flux = ... Wb [2]

[Total: 6]

3 **(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.

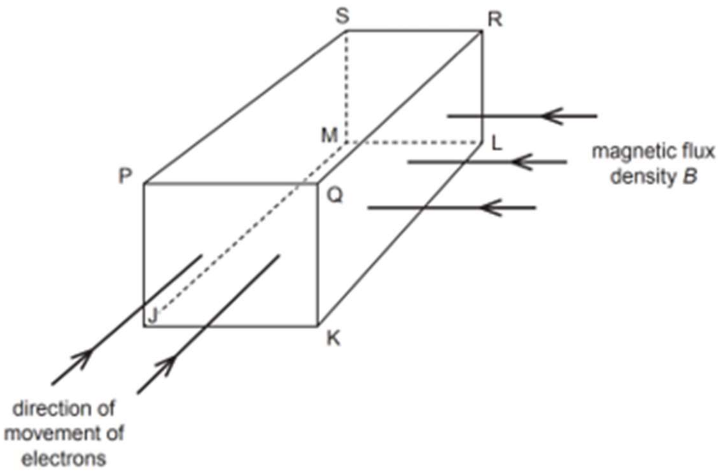

Fig. 6.1

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.

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

3 **(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.

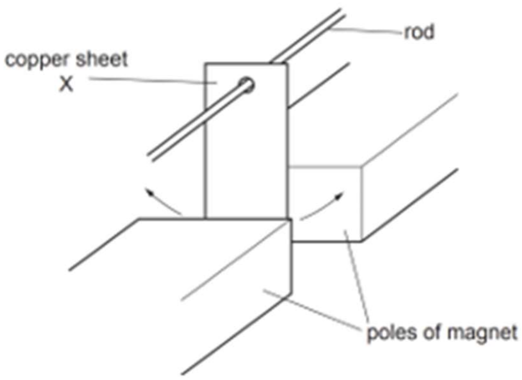

Fig. 6.2

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.

3 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.

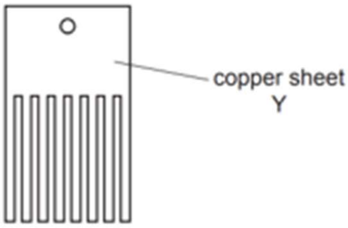

Fig. 6.3

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.

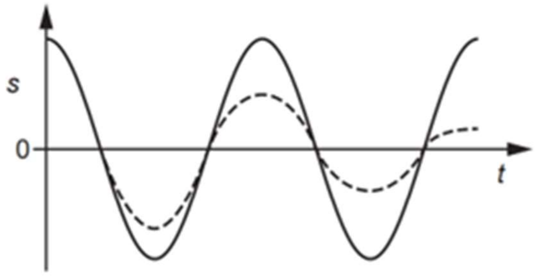

Fig. 6.4

(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.

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.... [4]

3 **(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.

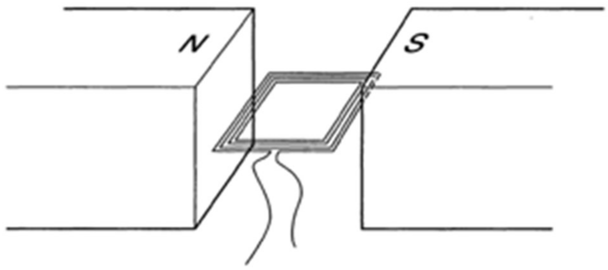

Fig. 6.5

(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.

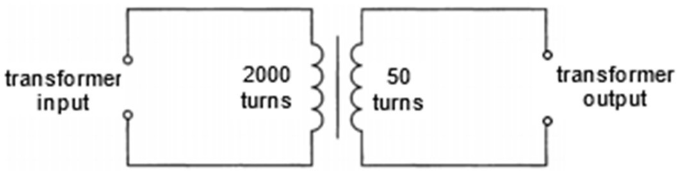

Fig. 6.6

Calculate the maximum voltage across the secondary coil.

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

3

(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.

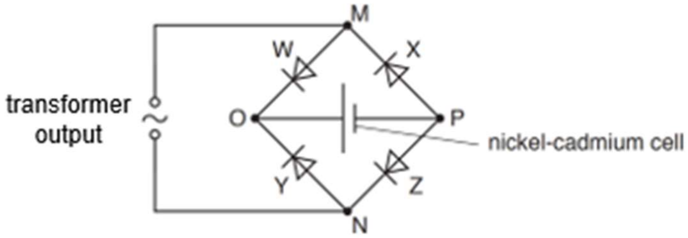

Fig. 6.7

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.

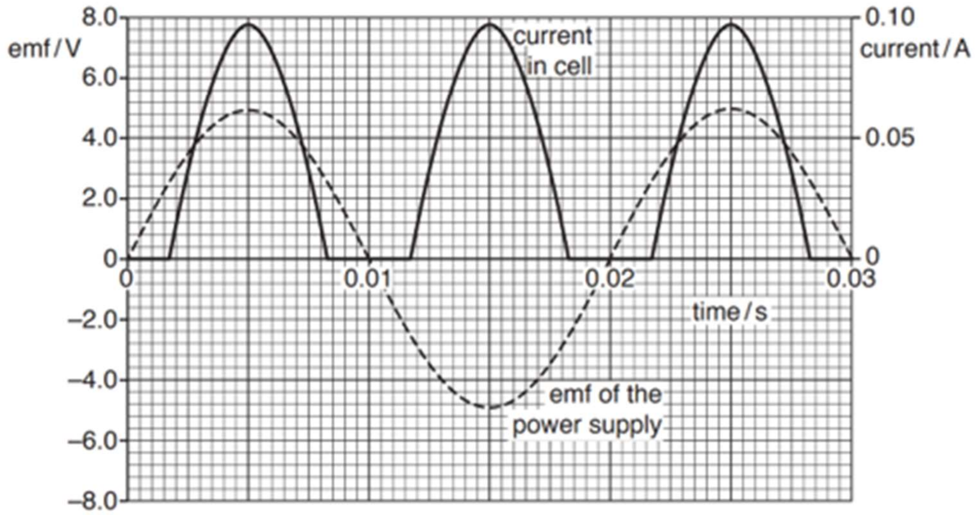

Fig. 6.8

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.

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.... [2]

3

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]

4 A rigid wire is pivoted at point P so that it is free to move in a vertical plane, as shown in Fig. 7.1. The lower end of the wire dips into mercury, which is contained in a conducting container. The arrangement is connected to a d.c. supply at points P and Q as shown. A uniform magnetic field of flux density 4.0×10^{-2} T acts over the region ABCD and is directed perpendicularly into the page. The length of sides AB and CD are 9.0 cm respectively.

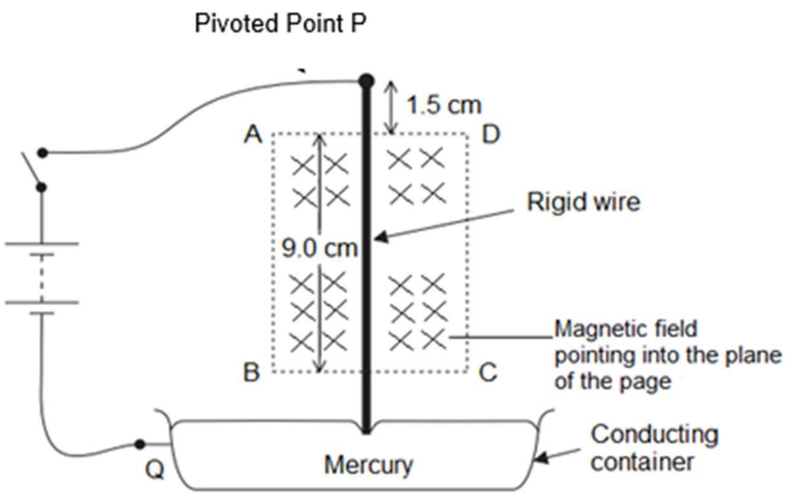

Fig. 7.1

(a) When the switch is closed the wire is seen to continually 'kick' out of the mercury and then return to it. Explain, with reference to the forces that act on the wire, why it moves like this.

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.... [3]

4 **(b)** The electromagnetic force on the wire may be assumed to act at the midpoint of the part of the wire which lies in the magnetic field. The initial moment of this force about P, produced when the switch is closed, is 5.0×10^{-4} N m.

Calculate the magnitude of the force.

force = ... N [2]

(c) If the diameter of the rigid wire is doubled and the length is kept constant, explain how the initial acceleration of the rod changes, if any. Assume that the resistance of the rigid wire is much greater than other resistances of the closed circuit.

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.... [3]

[Total: 8]

5 **(a)** State Faraday's law of electromagnetic induction.

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.... [1]

(b) Fig 5.1 shows a system used by an engineer to determine the constant rate of revolution of a rotating cylinder.

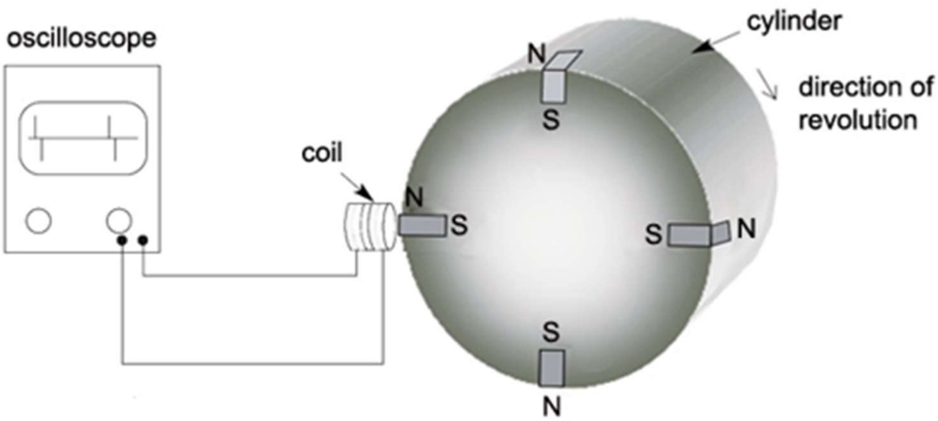

Fig. 5.1

Four small bar magnets are embedded in the cylinder as shown. The North-pole of each magnet is on the exterior of the cylinder. As the cylinder rotates, a voltage is produced between the terminals of a coil placed close to the cylinder.

The voltage produced is monitored using a cathode ray oscilloscope (c.r.o.). The waveform displayed on the c.r.o. is shown in Fig 5.2.

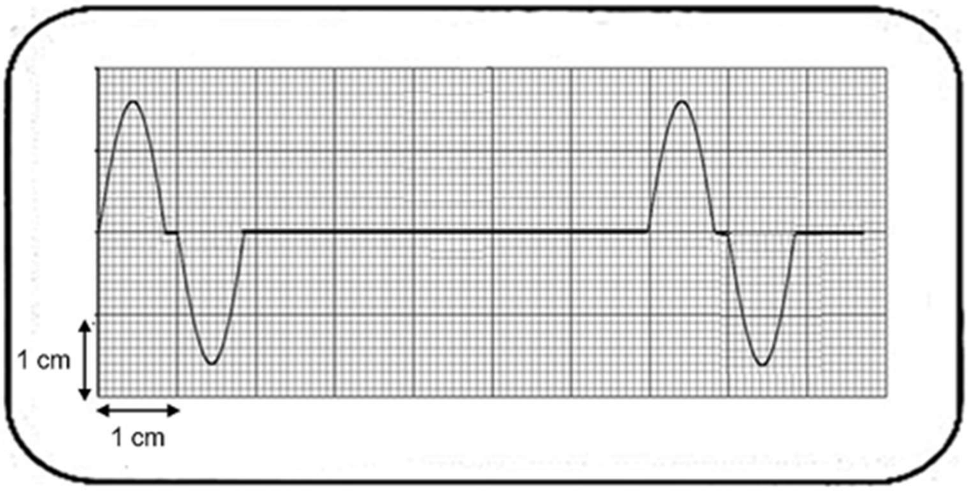

Fig. 5.2 (not to scale)

Given:

Y-plate sensitivity = 5.0 mV cm^{-1}

Time-base setting = 10 ms cm^{-1}

5

(i) Using the laws of electromagnetic induction, explain the shape of the waveform obtained in Fig. 5.2.

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.... [2]

(ii) Determine the number of revolutions made by the cylinder in one minute.

number of revolutions = ... [3]

(iii) Determine the maximum rate of change of magnetic flux linkage of the coil.

maximum rate of change of flux linkage = ... $Wb\ s^{-1}$ [1]

(iv) Describe and explain the changes, if any, to the waveform displayed in Fig. 5.2 when the rate of revolution of the cylinder is doubled.

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.... [3]

[Total: 10]