6 **(a)** In an experiment to determine the specific charge (e / m) for an electron, a beam of electrons, travelling horizontally in a vacuum with uniform speed v, enters a region R where uniform electric and magnetic fields can be applied. The electric field strength has a magnitude E and acts into the plane of the paper as shown in Fig. 6.1 below.

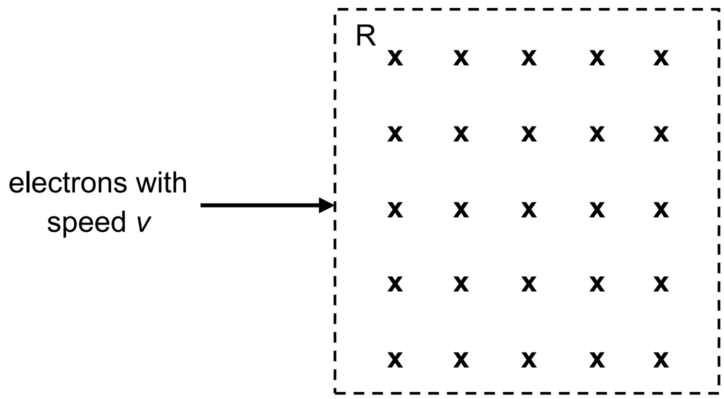

Fig. 6.1

The strength of the fields, when applied in combination, can be adjusted such that the beam remains undeflected when passing through R.

(i) Draw on Fig. 6.1 the magnetic field in region R so that the electron beam can pass through undeflected. Explain your answer.

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………………………………………………………………………………….… [3]

(ii) Electrons with speed of 3.3×10^{7} m s^{-1} are produced using an electron gun. The magnetic flux density of the magnetic field is 3.0×10^{-3} T.

1. Determine the electric field strength E required to produce an undeflected beam.

E = ………………………… N C^{-1} [2]

2. When the electric field is switched off, the electrons move in an arc of radius 6.0×10^{-2} m.

Deduce a value for the specific charge of an electron.

specific charge = ………………………... C kg^{-1} [3]

(b) A pair of concentric coils A and B is shown in Fig. 6.2.

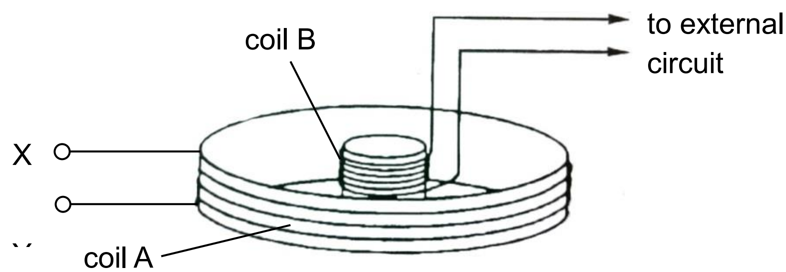

Fig. 6.2

The outer coil A is connected to a variable power supply by the terminals XY. The variation with time t of the current I in coil A is shown in Fig. 6.3.

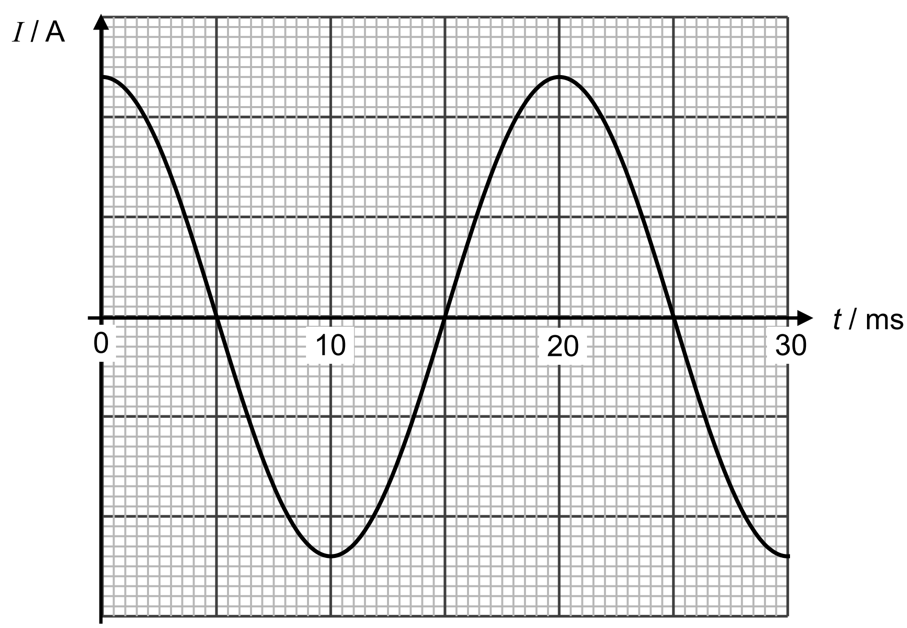

Fig. 6.3

(i) Using Faraday's law, explain why an e.m.f. is induced in coil B.

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(ii) At t = 25.0 ms, the induced e.m.f. in coil B is at its maximum value.

Using Fig. 6.3, explain why this is so.

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(iii) State the phase difference between the current in coil B and the current in coil A. Explain your answer.

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(iv) On Fig. 6.3, sketch the variation with time *t* of the induced current I_B in coil B. Values of the current are not required. [1]

(c) A graph of the input voltage *V* to an ideal transformer is shown in Fig. 6.4. The frequency of the input voltage is 50 Hz and the mean input power is 20 W. The turns ratio of the primary coil to the secondary coil is 50:1.

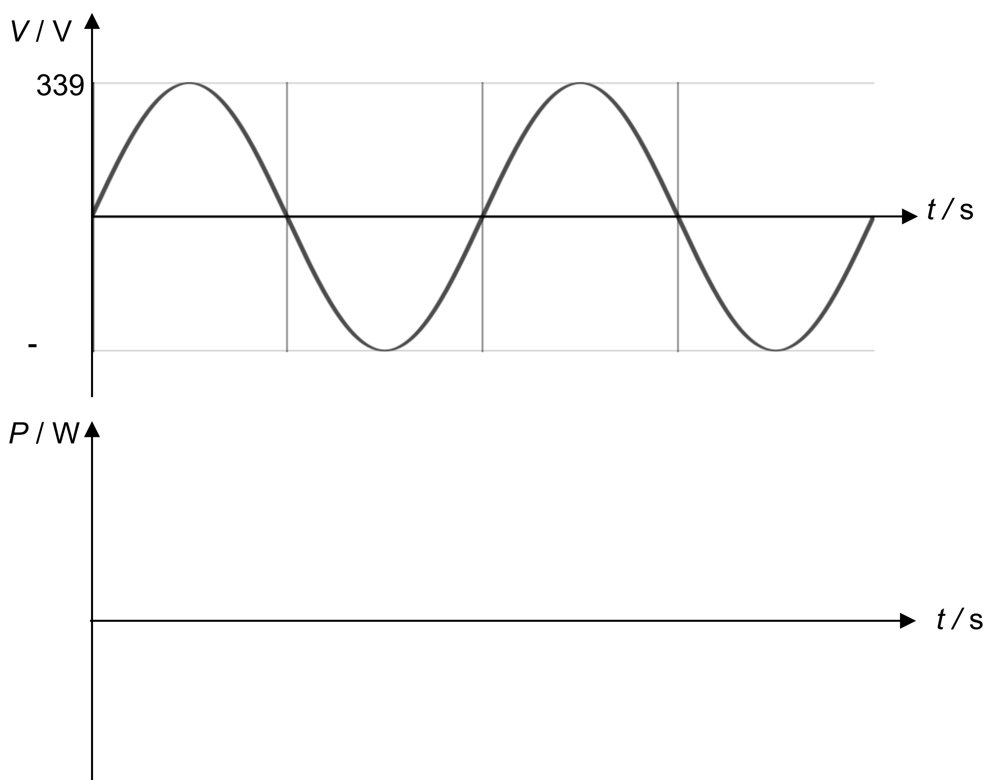

Fig. 6.4

(i) Sketch the variation with time of the input power to the transformer for two complete cycles in Fig. 6.4. [3]

(ii) Calculate the r.m.s. value of the output voltage V_s.

V_s = ………………………… V [2]