8 **(a)** Define *magnetic flux density.*

....

....

....

.... [3]

(b) A proton is travelling in a vacuum in a straight line with a speed of $6.2 \times 10^5\,\mathrm{m\,s^{-1}}$. It enters a region of uniform magnetic field of flux density B, as shown in Fig. 8.1.

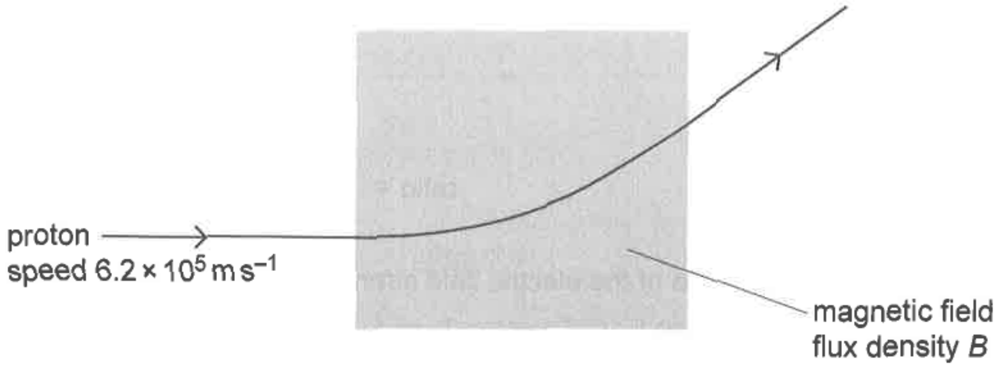

Fig. 8.1 (not to scale)

Initially, the proton is travelling in a direction normal to the magnetic field.
The proton follows a circular path in the magnetic field of radius 7.6 cm.

(i) Explain why the path in the magnetic field is an arc of a circle.

....

....

.... [2]

(ii) Calculate the magnetic flux density B.

B = ... T [2]

(c) A uniform electric field is now switched on in the same region as the magnetic field in **(b)**. The magnitude of the electric field is adjusted so that the proton moves undeviated through the two fields.

(i) On Fig. 8.1, draw an arrow to show the direction of the electric field. [1]

(ii) Determine the magnitude E of the electric field strength.

E = ... V m^{-1} [2]

(d) Two coils, P and S, are wound onto an iron core, as shown in Fig. 8.2.

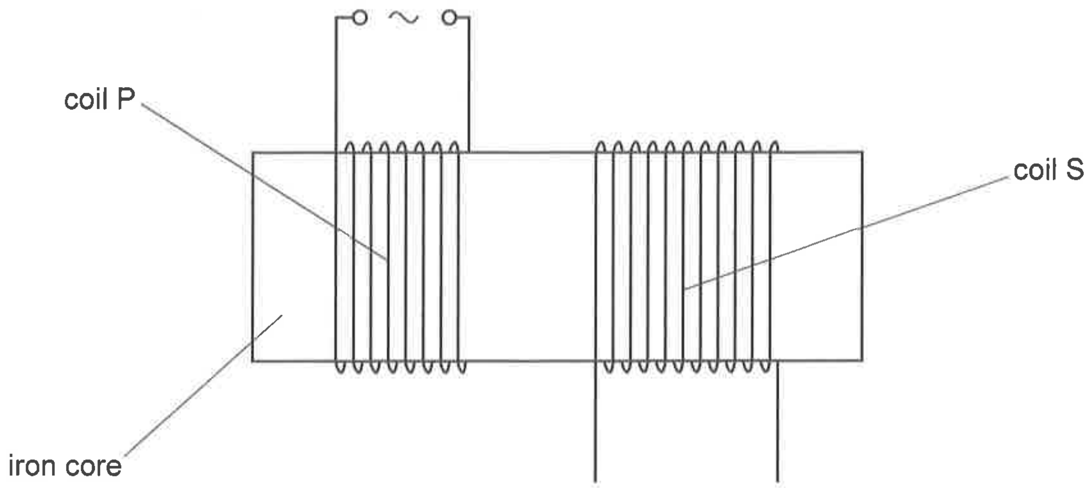

Fig. 8.2

A sinusoidal alternating current in coil P gives rise to an alternating magnetic flux in coil S.
The magnetic flux density is uniform throughout coil S.
The variation with time t of the uniform magnetic flux density B in coil S is shown in Fig. 8.3.

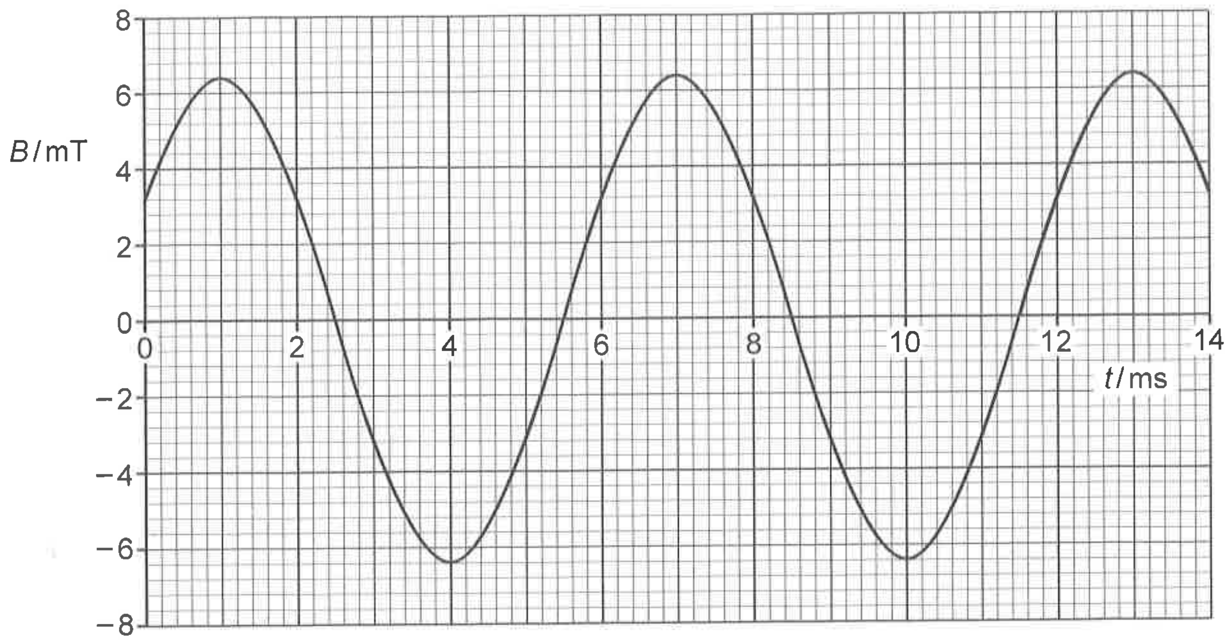

Fig. 8.3

(i) Calculate the root-mean-square (r.m.s.) value of the magnetic flux density in coil S.

r.m.s. value = ... mT [1]

(ii) State **two** times at which the electromotive force (e.m.f.) induced in coil S is zero.

time .... ms and time .... ms [1]

(e) The coil S in **(d)** contains 270 turns of wire. Each turn of wire has a diameter of 2.4 cm.

Use data from Fig. 8.3 to determine the maximum e.m.f. induced in coil S.

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

(f) The alternating current in coil P in **(d)** is now replaced by a direct current that is reversed at regular time intervals.
The variation with time t of the magnetic flux ϕ in coil S is shown in Fig. 8.4.

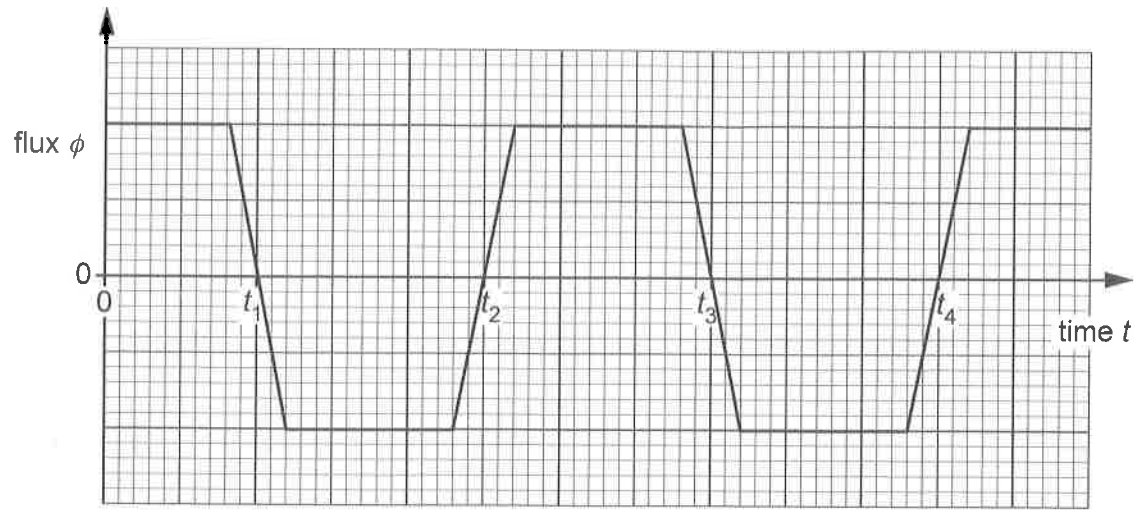

Fig. 8.4

Use data from Fig. 8.4 to sketch, on Fig. 8.5, the variation with time t of the e.m.f. induced in coil S.

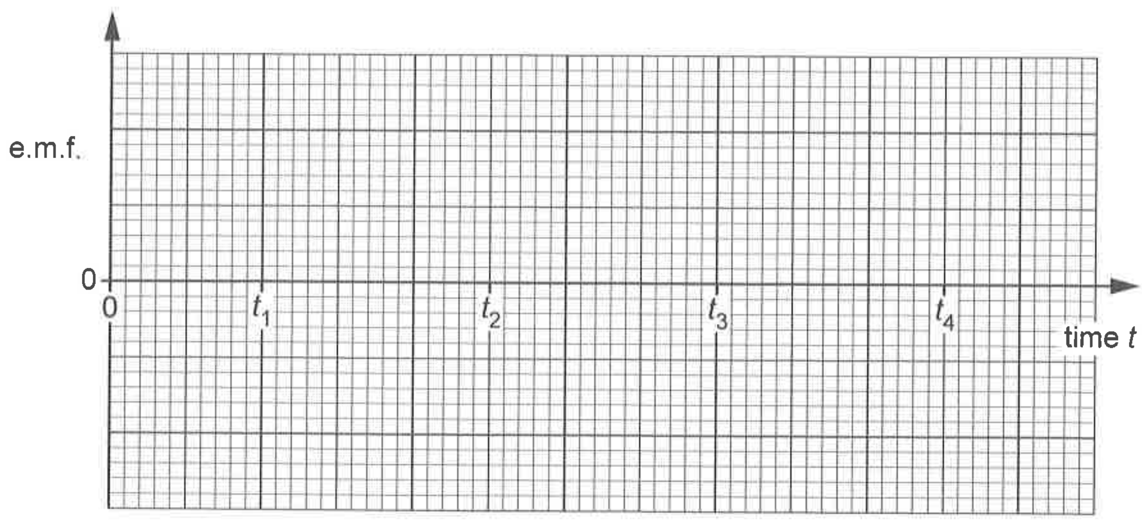

Fig. 8.5

[4]

[Total: 20]