4 An electron in a metal rod moves randomly about a mean position. When an alternating voltage is applied to the ends of the rod, the mean position can be considered to oscillate with simple harmonic motion along the axis of the rod. Fig. 4.1 shows the variation with time *t* of the displacement *x* of the mean position from a fixed point on the axis of the rod.

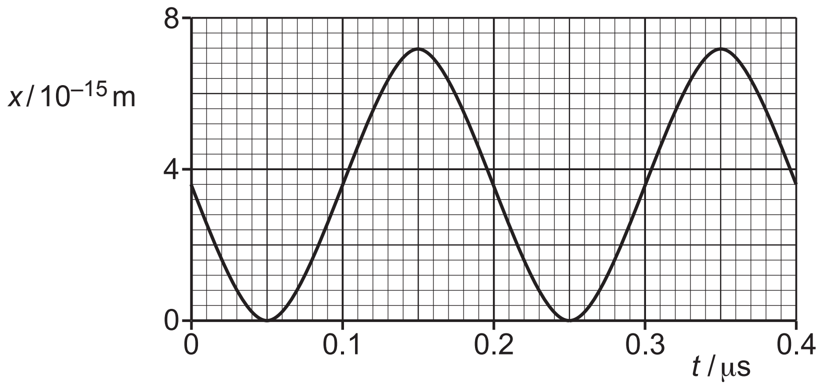

Fig. 4.1

(a) **(i)** Determine the amplitude of the oscillations.

amplitude = ... m [1]

(ii) Determine the angular frequency of the oscillations.

angular frequency = ... rad s^{-1} [1]

(iii) Use your answers in **(a)(i)** and **(a)(ii)** to show that the maximum drift speed v_0 of the electron is $1.1 \times 10^{-7}\,m\,s^{-1}$.

[2]

(b) The rod has a cross-sectional area of $4.3\,\text{cm}^2$ and contains a number density of conduction electrons (charge carriers) of $8.5 \times 10^{28}\,\text{m}^{-3}$.

All of the conduction electrons in the rod may be assumed to be oscillating in phase with, and with the same amplitude as, the oscillation shown in Fig. 4.1.

(i) Use the information in **(a)(iii)** to calculate the magnitude I_0 of the maximum current in the rod.

I_0 = ...A [2]

(ii) On Fig. 4.2, sketch the variation of the current I in the rod with time t between $t = 0$ and $t = 0.40\,\mu\text{s}$.

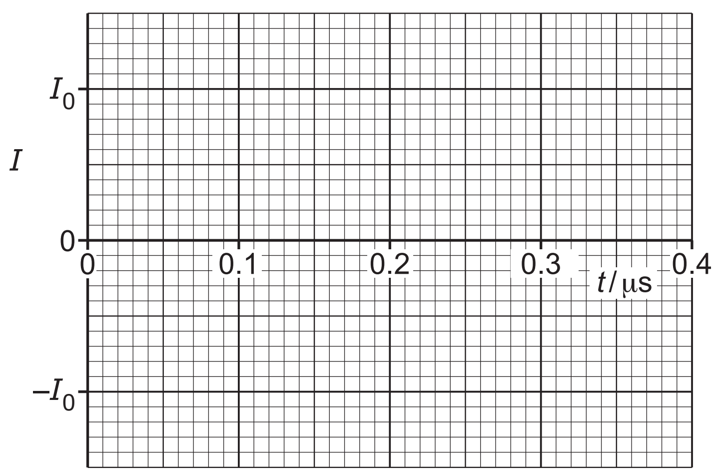

Fig. 4.2

[2]

(iii) Use your answers in **(a)(ii)** and **(b)(i)** to determine an expression for I in terms of t, where I is in A and t is in s.

I = ... [2]

(iv) Determine the root-mean-square (r.m.s.) current in the rod.

r.m.s. current = ...A [1]

[Total: 11]