7 An alternating voltage V varies with time t according to

$$V = 18\cos 40\pi t$$

where V is in V and t is in s.

(a) For the alternating voltage:

(i) show that the period is 0.050 s

[1]

(ii) determine the root-mean-square (r.m.s.) voltage.

r.m.s. voltage = ... V [1]

(b) On Fig. 7.1, sketch the variation of V with t for values of t from $t = 0$ to $t = 100$ ms.

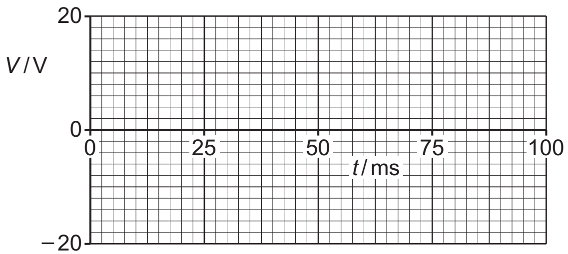

Fig. 7.1

[3]

(c) The alternating voltage is rectified to produce an output voltage across a load resistor R, as shown in Fig. 7.2.

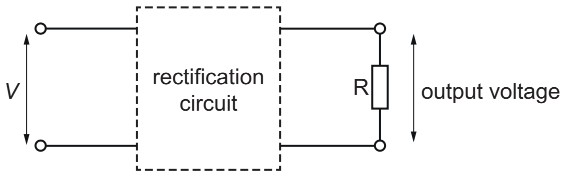

Fig. 7.2

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Fig. 7.3 shows the variation with t of the power P in the load resistor.

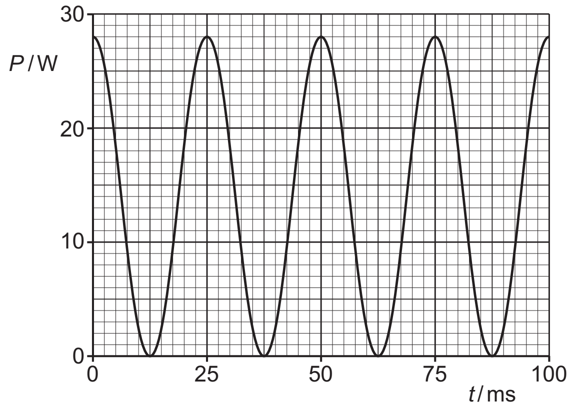

Fig. 7.3

State **three** conclusions that can be drawn from Fig. 7.3. The conclusions may be qualitative or quantitative. Use the space for any working.

1 ....

....

2 ....

....

3 ....

....

[3]

[Total: 8]

7 A circuit contains a power supply that provides a sinusoidal alternating input voltage V_{IN}. There is an output voltage V_{OUT} across a load resistor R, as shown in Fig. 7.1.

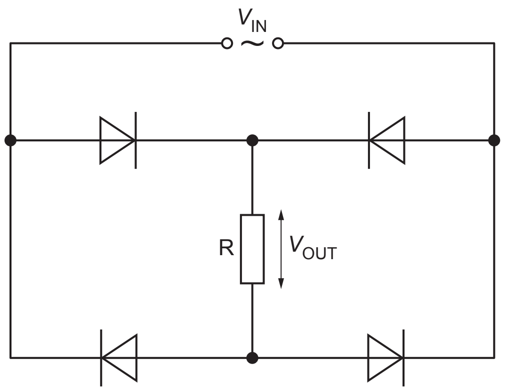

Fig. 7.1

(a) State the purpose of the circuit in Fig. 7.1.

....

....

.... [2]

(b) Fig. 7.2 shows the variation of V_{OUT} with time t.

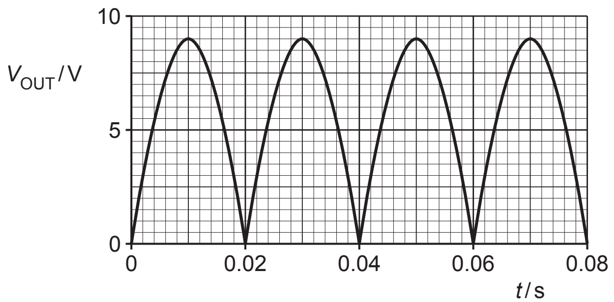

Fig. 7.2

(i) The load resistor R has a resistance of 370 Ω.

Show that the maximum power dissipated in R is 0.22 W.

[2]

(ii) On Fig. 7.3, sketch the variation with t of the power P dissipated in R.

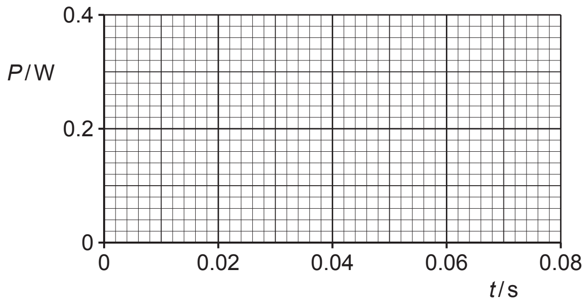

Fig. 7.3

[3]

(iii) Calculate the mean power dissipated in R.

mean power = ... W [1]

(c) The circuit of Fig. 7.1 is disconnected, and R is connected directly across the power supply.

Explain, without calculation, how the mean power now dissipated in R compares with the answer in **(b)(iii)**.

....

....

.... [2]

[Total: 10]

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.

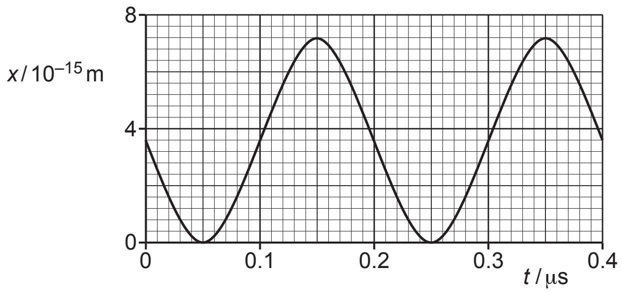

Fig. 4.1

(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 1.1×10^{-7} m s^{-1}.

[2]

(b) The rod has a cross-sectional area of 4.3 cm^2 and contains a number density of conduction electrons (charge carriers) of 8.5×10^{28} 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 μs.

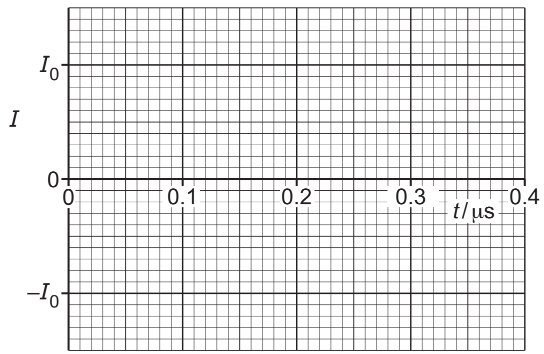

Fig. 4.2

[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]

7 A varying current I passes through a resistor of resistance R in the circuit shown in Fig. 7.1.

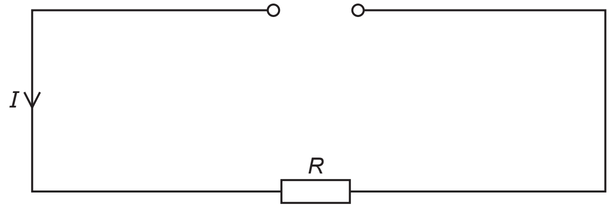

Fig. 7.1

Fig. 7.2 shows the variation with time t of I.

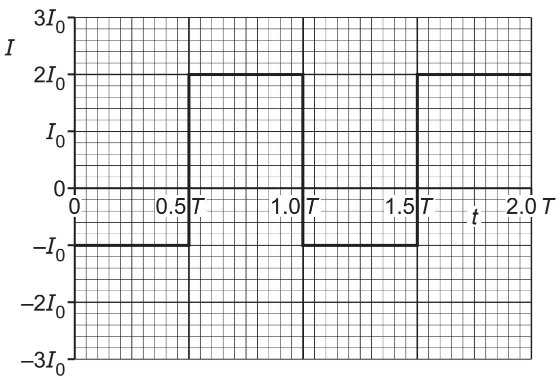

Fig. 7.2

The current has magnitude $2I_0$ when it is in the positive direction and I_0 when it is in the negative direction. The period of the variation of the current is T.

(a) Determine expressions, in terms of I_0 and R, for the power P dissipated in the resistor for the times when:

(i) the current is in the negative direction

P = ... [1]

(ii) the current is in the positive direction.

P = ... [1]

(b) On Fig. 7.3, sketch the variation of P with t between t = 0 and t = 2.0T. Label the power axis with an appropriate scale.

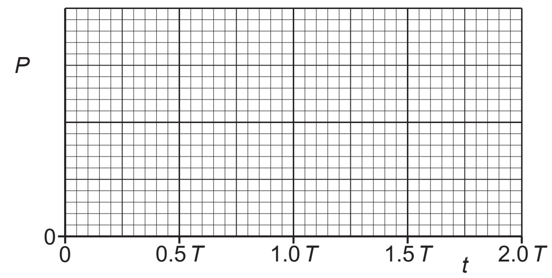

Fig. 7.3

[3]

(c) Use your answer in **(b)** to determine an expression, in terms of I_0 and R, for:

(i) the mean power $\langle P \rangle$ in the resistor

$\langle P \rangle$ = ... [1]

(ii) the root-mean-square (r.m.s.) current $I_{r.m.s.}$ in the resistor.

$I_{r.m.s.}$ = ... [2]

[Total: 8]