Cambridge International

Examambuddy

PHYSICS

Alternating currents

9702

1 **(a)** Alternating current (a.c.) is converted into direct current (d.c.) using a full-wave rectification circuit. Part of the diagram of this circuit is shown in Fig. 7.1.

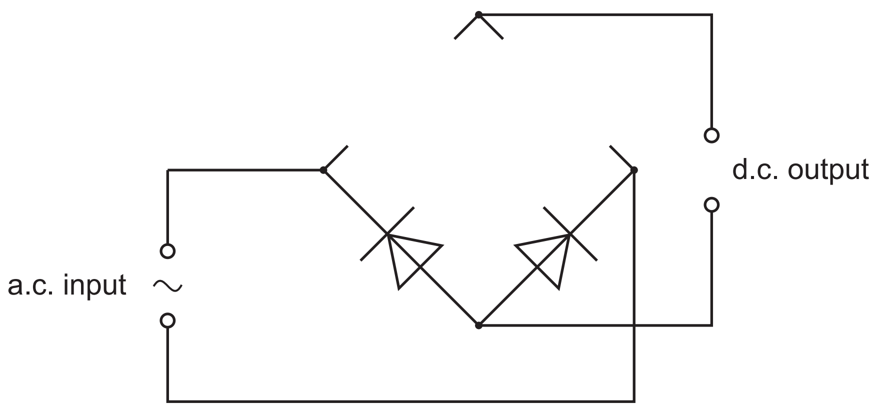

Fig. 7.1

(i) Complete the circuit in Fig. 7.1 by adding the necessary components in the gaps. [1]

(ii) On Fig. 7.1 mark with a + the positive output terminal of the rectifier. [1]

(b) The output voltage *V* of an a.c. power supply varies sinusoidally with time *t* as shown in Fig. 7.2.

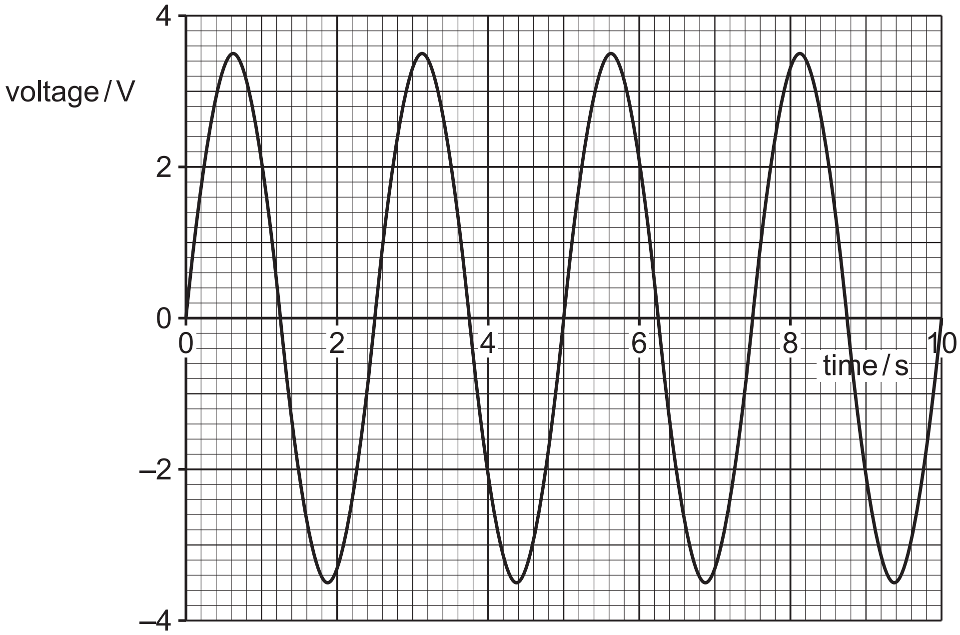

Fig. 7.2

(i) Determine the equation for *V* in terms of *t*, where *V* is in volts and *t* is in seconds.

V = ... [2]

(ii) The supply is connected to a 12 Ω resistor. Calculate the mean power dissipated in the resistor.

mean power = ... W [2]

[Total: 6]

9702/41/M/J/22

2 Fig. 5.1 shows four diodes and a load resistor of resistance 1.2 kΩ, connected in a circuit that is used to produce rectification of an alternating voltage.

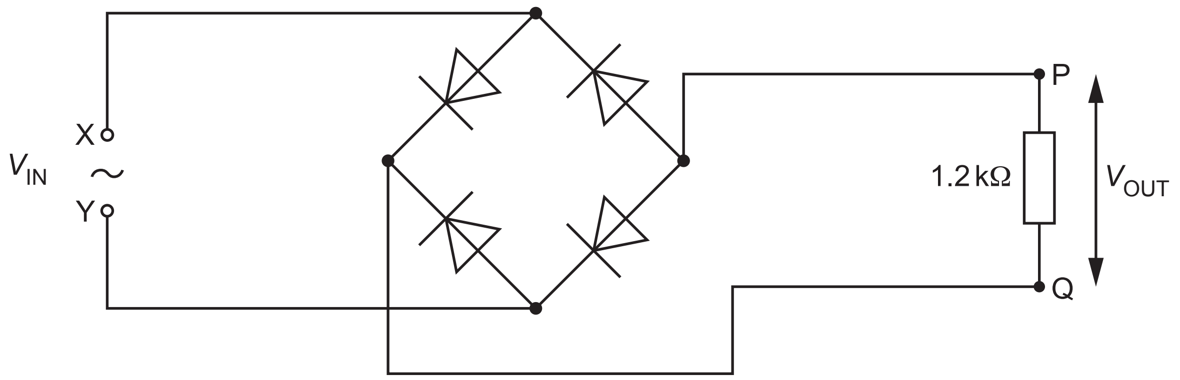

Fig. 5.1

(a) **(i)** State what is meant by rectification.

....

.... [1]

(ii) State the type of rectification produced by the circuit in Fig. 5.1.

.... [1]

(b) A sinusoidal alternating voltage V_{IN} is applied across the input terminals X and Y. The variation with time t of V_{IN} is given by the equation

$$V_{IN} = 6.0 \sin 25\pi t$$

where V_{IN} is in volts and t is in seconds.

(i) On Fig. 5.1, label the output terminals P and Q with the appropriate symbols to indicate the polarity of the output voltage V_{OUT}. [1]

(ii) The magnitude of the output voltage V_{OUT} varies with t as shown in Fig. 5.2.

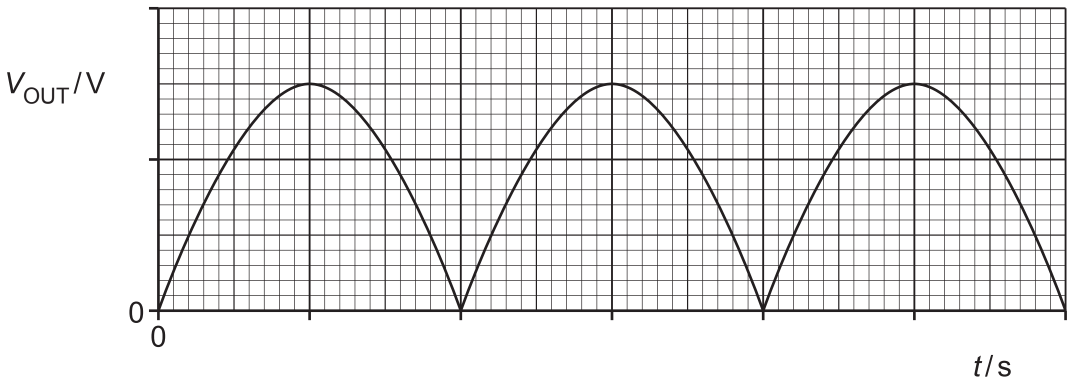

Fig. 5.2

On Fig. 5.2, label both of the axes with the correct scales. Use the space below for any working that you need.

[3]

(c) The output voltage in **(b)** is smoothed by adding a capacitor to the circuit in Fig. 5.1. The difference between the maximum and minimum values of the smoothed output voltage is 10% of the peak voltage.

(i) On Fig. 5.1, draw the circuit symbol for a capacitor showing the capacitor correctly connected into the circuit. [1]

(ii) On Fig. 5.2, sketch the variation with t of the smoothed output voltage. [2]

(iii) Calculate the capacitance C of the capacitor.

C = ... F [3]

[Total: 12]

9702/42/F/M/21

3 The output potential difference (p.d.) of an alternating power supply is represented by

$$V = 320\sin(100\pi t)$$

where V is the p.d. in volts and t is the time in seconds.

(a) Determine the root-mean-square (r.m.s.) p.d. of the power supply.

r.m.s. p.d. = ... V [1]

(b) Determine the period T of the output.

T = ... s [2]

(c) The power supply is connected to resistor R and a diode in the circuit shown in Fig. 10.1.

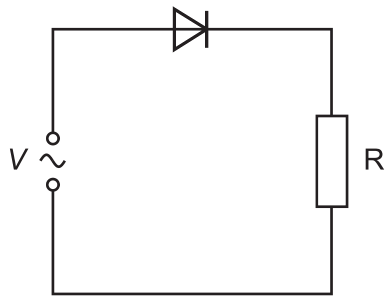

Fig. 10.1

(i) State the name of the type of rectification produced by the diode in Fig. 10.1.

.... [1]

(ii) On Fig. 10.2 sketch the variation with time t of the p.d. V_R across R from time t = 0 to time t = 40 ms.

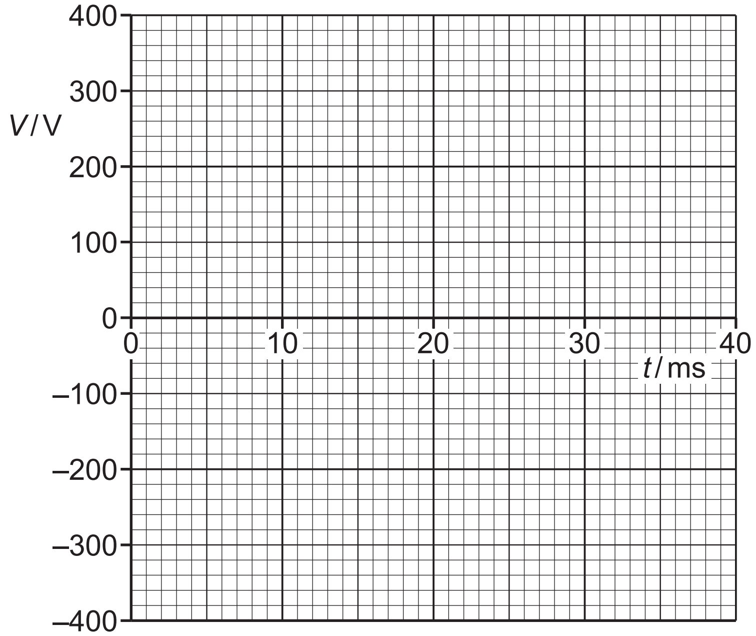

Fig. 10.2

[3]

(iii) On Fig. 10.1, draw the symbol for a component that may be connected to produce smoothing of V_R.

[1]

[Total: 8]

9702/42/M/J/21

4 **(a)** By reference to heating effect, explain what is meant by the *root-mean-square* (*r.m.s.*) value of an alternating current.

....

....

.... [2]

(b) The variations with time *t* of two currents I_1 and I_2 are shown in Fig. 10.1 and Fig. 10.2.

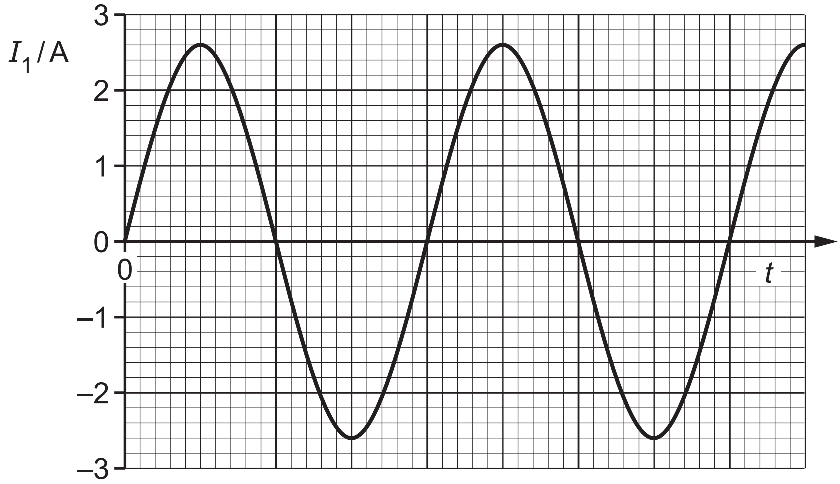

Fig. 10.1

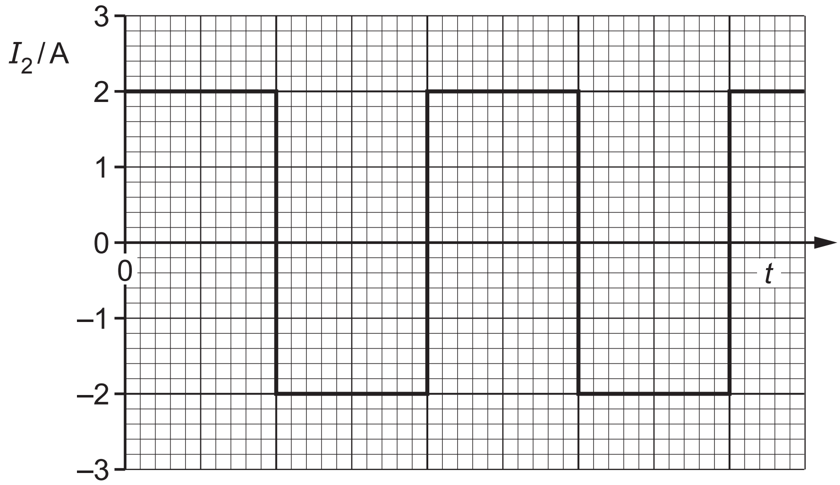

Fig. 10.2

(i) Use Fig. 10.1 to determine the peak value and the r.m.s. value of the current I_1.

peak value = ... A

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

(ii) Use Fig. 10.2 to determine the peak value and the r.m.s. value of the current I_2.

peak value = ... A

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

(c) The variation with time t of the supply voltage V to a house is given by the expression

$$V = 240 \sin kt$$

where V is in volts, t is in seconds and k is a constant with unit rad s^{-1}.

(i) The frequency of the supply voltage is 50 Hz.

Determine k to two significant figures.

k = ... rad s^{-1} [2]

(ii) The supply voltage is applied to a heater. The mean power of the heater is 3.2 kW.

Calculate the resistance of the heater.

resistance = ... Ω [2]

[Total: 8]

5 (a) State, by reference to the power dissipated in a resistor, what is meant by the *root-mean-square* (*r.m.s.*) value of an alternating voltage.

....

....

....

.... [2]

(b) A coil is rotating freely, on frictionless bearings, at constant speed in a uniform magnetic field. This rotation causes an induced alternating electromotive force (e.m.f.) across the open terminals of the coil. The induced e.m.f. has r.m.s. value 12 V and frequency 50 Hz.

The speed of rotation of the coil is now doubled.

(i) State and explain, with reference to the principles of electromagnetic induction, the effect of the increased speed of rotation on the r.m.s. value of the induced e.m.f.

....

....

....

.... [2]

(ii) On Fig. 9.1, sketch the variation with time t of the induced e.m.f. E across the terminals of the coil at the **increased** speed of rotation. Your line should extend from time t = 0 to time t = 20 ms. Assume that E = 0 when t = 0.

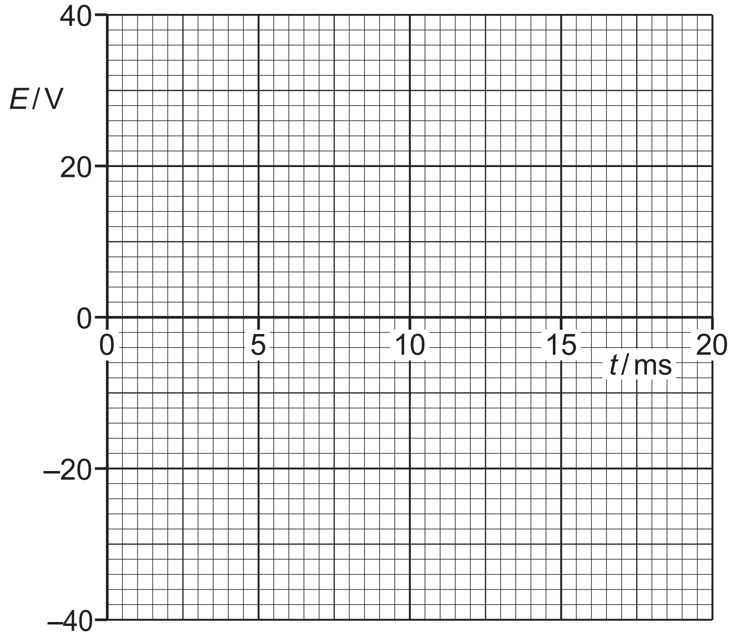

Fig. 9.1

[3]

(c) State and explain the effect on the motion of the coil in **(b)** of connecting a load resistor across its terminals.

....

....

....

.... [2]

[Total: 9]

9702/42/O/N/21

6 Fig. 10.1 shows a simple laminated iron-cored transformer consisting of a primary coil of 25 000 turns and a secondary coil of 625 turns.

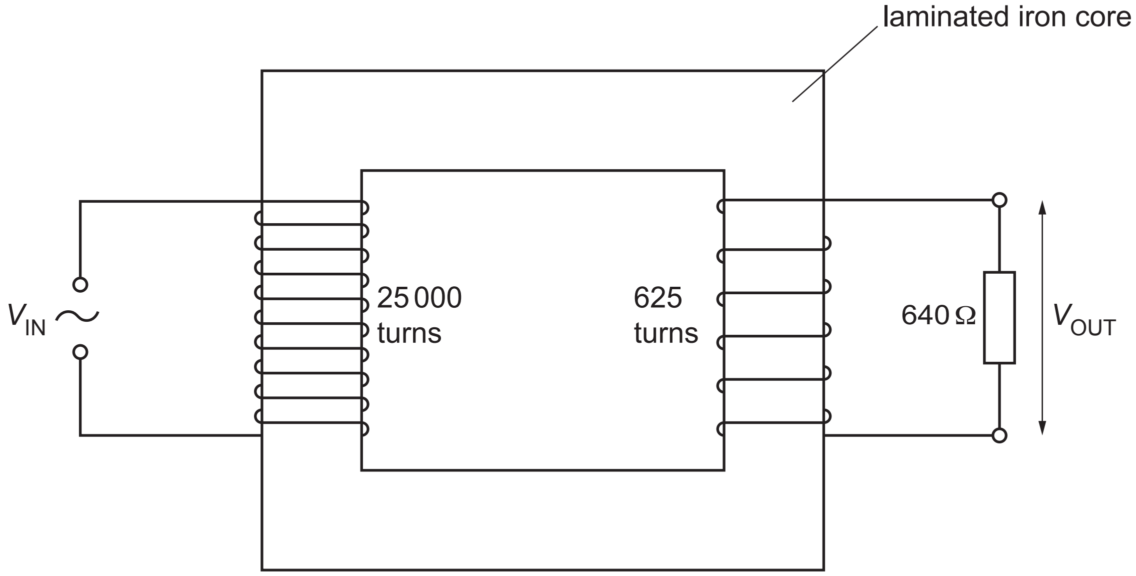

Fig. 10.1

The output potential difference (p.d.) V_{OUT} is applied to a load resistor of resistance 640 Ω.

(a) **(i)** State the function of the iron core.

....

.... [1]

(ii) Explain why the iron core is laminated.

....

....

.... [2]

(b) The input p.d. V_{IN} is a sinusoidal alternating voltage of peak value 12 kV and period 40 ms.

(i) Calculate the maximum value of V_{OUT}.

maximum V_{OUT} = ... V [1]

(ii) Calculate the root-mean-square (r.m.s.) current in the load resistor.

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

(iii) On Fig. 10.2, sketch the variation with time t of the power P dissipated in the load resistor for time t = 0 to t = 40 ms. Assume that P = 0 when t = 0.

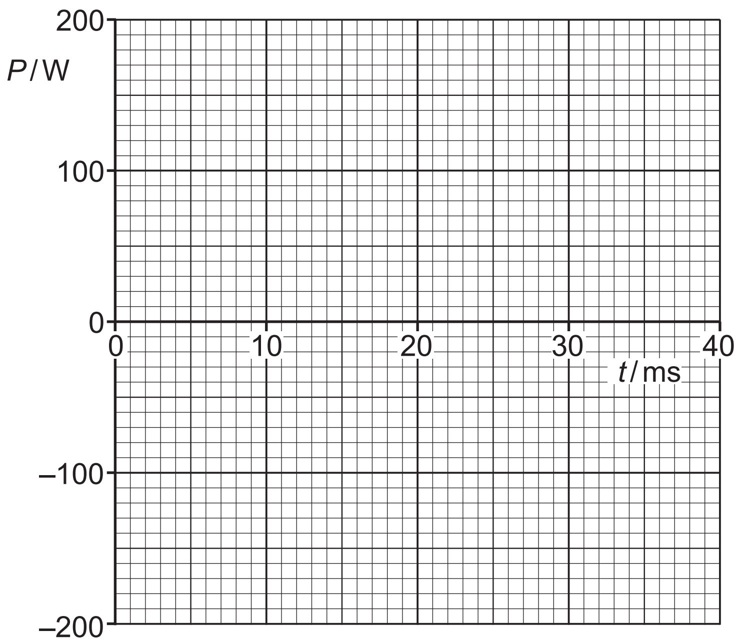

Fig. 10.2

[3]

(c) Explain, with reference to Fig.10.2, why the mean power in the load resistor is 70 W.

....

....

....

.... [2]

[Total: 10]

9702/42/F/M/20

7 **(a)** The output of a power supply is represented by:

$$V = 9.0 \sin 20t$$

where V is the potential difference in volts and t is the time in seconds.

Determine, for the output of the supply:

(i) the root-mean-square (r.m.s.) voltage, $V_{r.m.s.}$

$V_{r.m.s}$ = ... V [1]

(ii) the period T.

T = ... s [2]

(b) The variations with time t of the output potential difference V from two different power supplies are shown in Fig. 9.1 and Fig. 9.2.

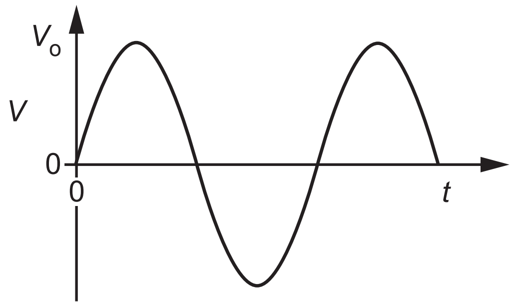

Fig. 9.1

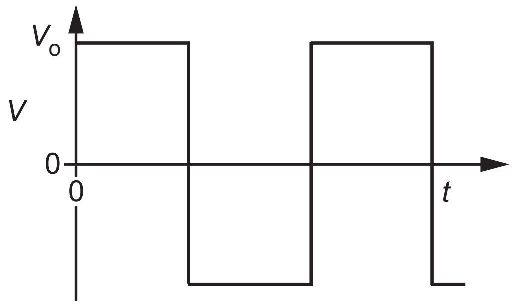

Fig. 9.2

The graphs are drawn to the same scale.

State and explain whether the same power would be dissipated in a 1.0 Ω resistor connected to each power supply.

....

....

.... [1]

(c) **(i)** The power supply in **(a)** is connected to a transformer. The input power to the transformer is 80 W.

The secondary coil is connected to a resistor. The r.m.s. voltage across the resistor is 120 V. The r.m.s. current in the secondary coil is 0.64 A.

Calculate the efficiency of the transformer.

efficiency = ... [3]

(ii) State **one** reason why the transformer is not 100% efficient.

....

.... [1]

[Total: 8]

8 A bridge rectifier contains four diodes. The output of the rectifier is connected to a resistor R, as shown in Fig. 10.1.

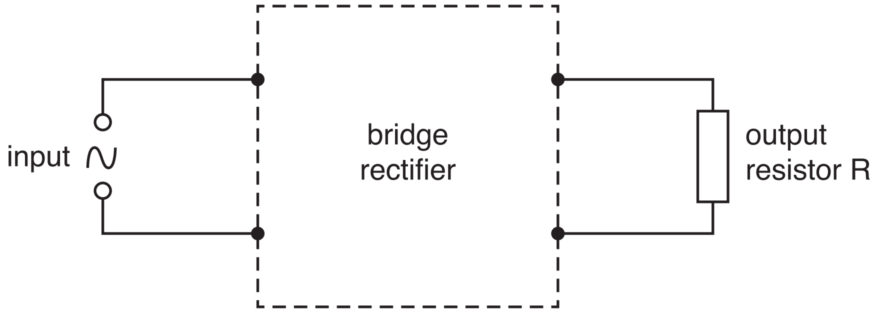

Fig. 10.1

The variation with time t of the input e.m.f. E to the rectifier is given by the expression

$$E = 15\cos(210t)$$

where t is measured in seconds and E in volts.

The variation with time t of the potential difference V across resistor R is shown in Fig. 10.2.

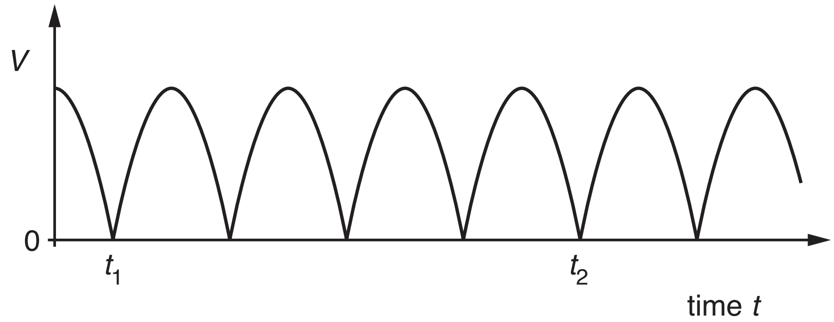

Fig. 10.2

Determine:

(a) the maximum potential difference V_{MAX} across resistor R

V_{MAX} = ... V [1]

(b) the time interval, to two significant figures, between time t_1 and time t_2.

time = ... s [3]

[Total: 4]

9702/42/M/J/19

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

....

....

....[2]

(b) An ideal transformer is illustrated in Fig. 10.1.

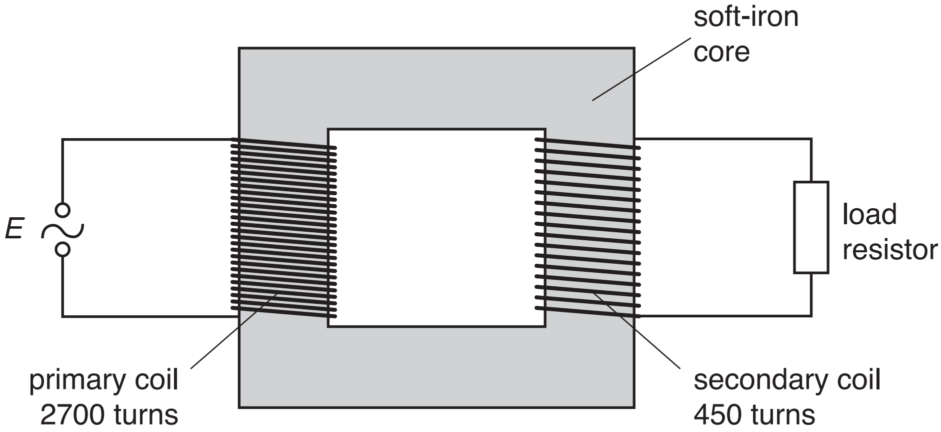

Fig. 10.1

Explain why, when there is an alternating current in the primary coil, there is a current in the load resistor.

....

....

....

....

....[3]

(c) The primary coil in **(b)** has 2700 turns. The secondary coil has 450 turns.

The e.m.f. E applied across the primary coil is given by the expression

$$E = 220\sin(100\pi t)$$

where E is measured in volts and t is the time in seconds.

Calculate the root-mean-square (r.m.s.) e.m.f. induced in the secondary coil.

r.m.s. e.m.f. = ... V [3]

[Total: 8]

9702/41/O/N/19

10 A bridge rectifier using four ideal diodes is shown in Fig. 10.1.

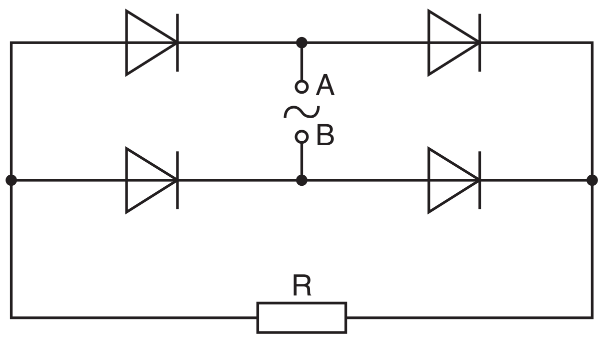

Fig. 10.1

The sinusoidal alternating electromotive force (e.m.f.) applied between points A and B has a root-mean-square (r.m.s.) value of 7.0 V.

(a) **(i)** On Fig. 10.1, circle the diodes that conduct when point B is positive with respect to point A. [1]

(ii) Calculate the maximum potential difference V_{MAX} across resistor R.

V_{MAX} = ... V [1]

(b) A capacitor is connected into the circuit to produce smoothing of the potential difference across resistor R.

The variation with time *t* of the potential difference *V* across resistor R is shown in Fig. 10.2.

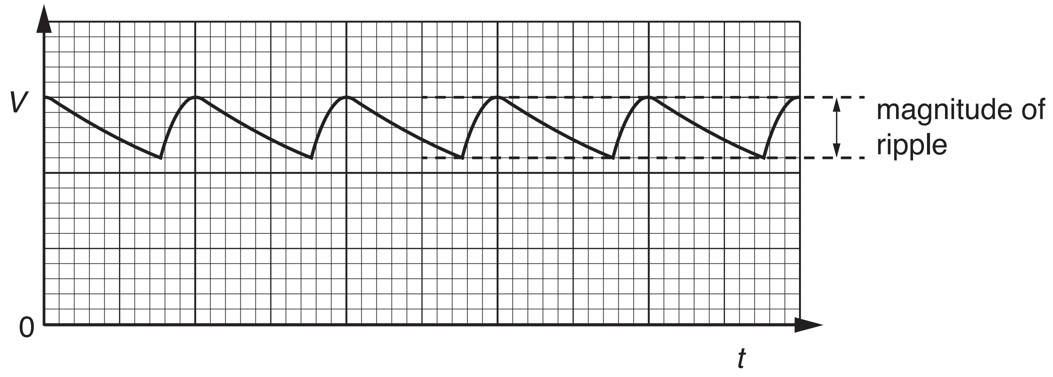

Fig. 10.2

(i) On Fig. 10.1, draw the symbol for a capacitor, connected so as to produce smoothing. [1]

(ii) State the effect, if any, on the magnitude of the ripple on *V* when, separately:

1. a capacitor of larger capacitance is used

....

2. the resistor R has a smaller resistance.

....
[2]

[Total: 5]

9702/42/F/M/17

11 An ideal transformer is shown in Fig. 9.1.

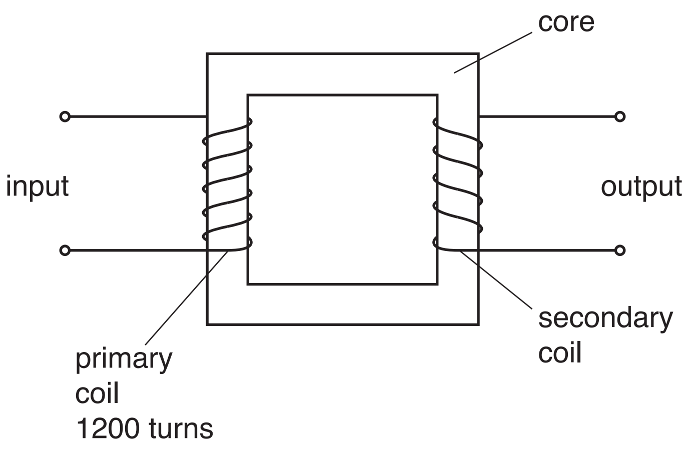

Fig. 9.1

(a) Explain

(i) why the core is made of iron,

....

....[1]

(ii) why an electromotive force (e.m.f.) is not induced at the output when a constant direct voltage is at the input.

....

....

....[2]

(b) An alternating voltage of peak value 150 V is applied across the 1200 turns of the primary coil. The variation with time *t* of the e.m.f. *E* induced across the secondary coil is shown in Fig. 9.2.

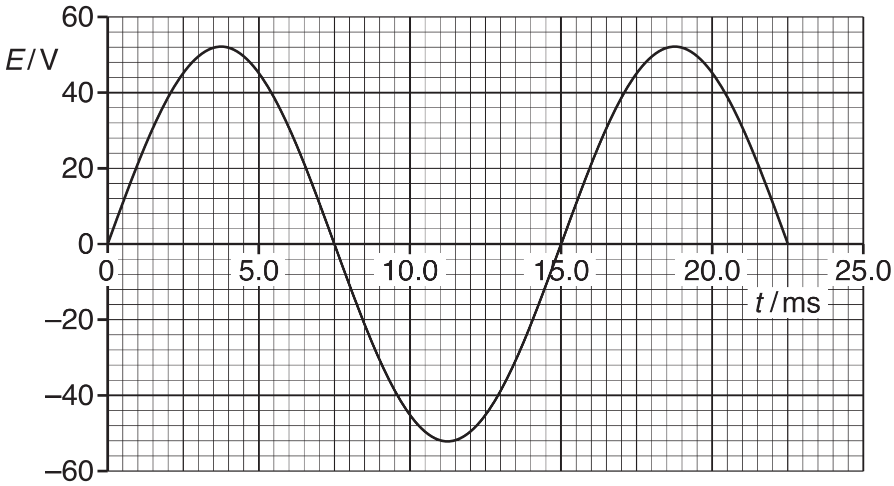

Fig. 9.2

Use data from Fig. 9.2 to

(i) calculate the number of turns of the secondary coil,

number = ...[2]

(ii) state one time when the magnetic flux linking the secondary coil is a maximum.

time = ... ms [1]

(c) A resistor is connected between the output terminals of the secondary coil. The mean power dissipated in the resistor is 1.2 W. It may be assumed that the varying voltage across the resistor is equal to the varying e.m.f. E shown in Fig. 9.2.

(i) Calculate the resistance of the resistor.

resistance = ... Ω [2]

(ii) On Fig. 9.3, sketch the variation with time t of the power P dissipated in the resistor for $t = 0$ to $t = 22.5$ ms.

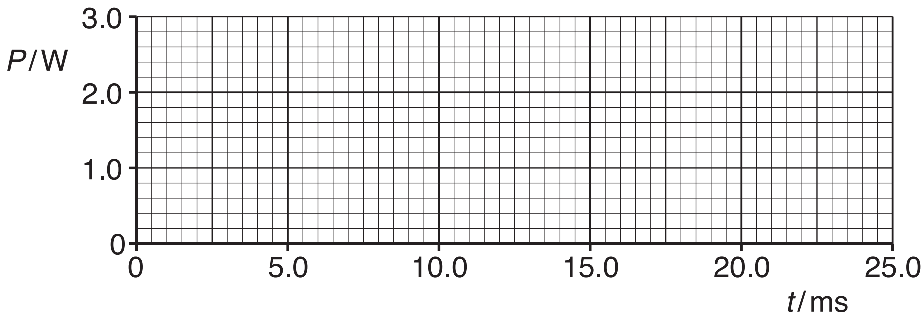

Fig. 9.3

[3]

[Total: 11]

9702/41/O/N/17

12 **(a)** The mean value of an alternating current is zero.
Explain why heating occurs when there is an alternating current in a resistor.

....

....

....

.... [2]

(b) Transmission of electrical energy is frequently achieved using alternating high voltages.
Suggest why

(i) high voltages are used,

....

....

....

.... [2]

(ii) the voltage is alternating.

....

....

....

.... [2]

[Total: 6]

9702/42/O/N/17

13 The circuit for a full-wave rectifier using four ideal diodes is shown in Fig. 11.1.

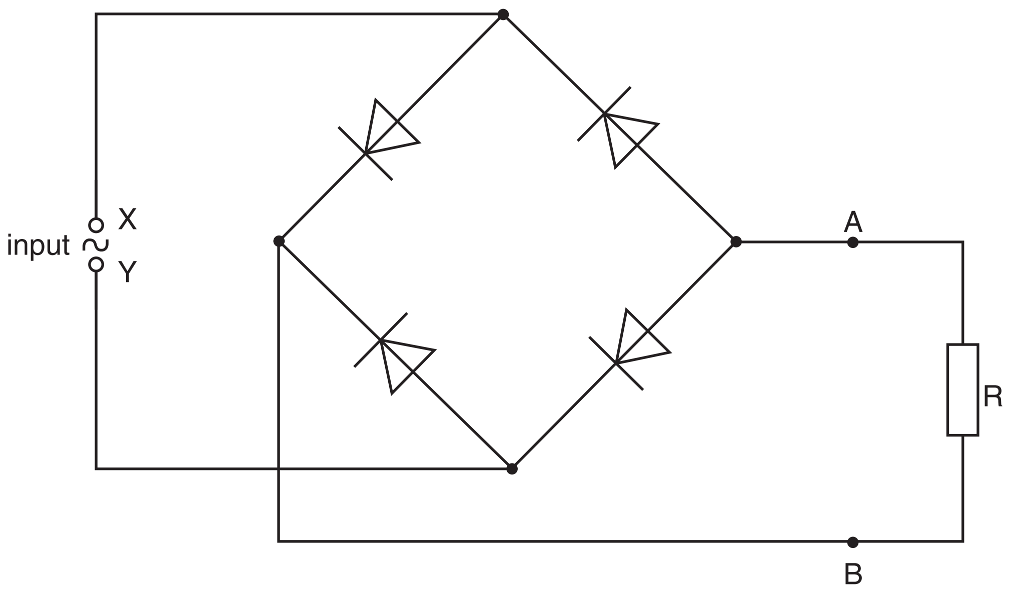

Fig. 11.1

A resistor R is connected across the output AB of the rectifier.

(a) On Fig. 11.1,

(i) draw a circle around any diodes that conduct when the terminal X of the input is positive with respect to terminal Y, [1]

(ii) label the positive (+) and the negative (–) terminals of the output AB. [1]

(b) The variation with time t of the potential difference V across the input XY is given by the expression

$$V = 5.6 \sin 380t$$

where V is measured in volts and t is measured in seconds.

The variation with time t of the rectified potential difference across the resistor R is shown in Fig. 11.2.

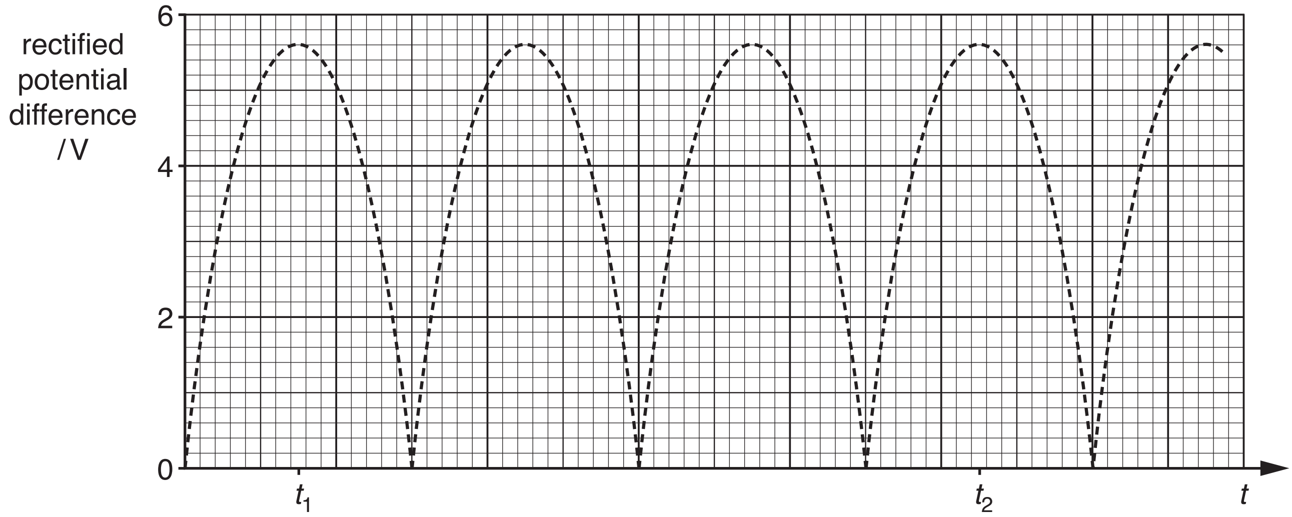

Fig. 11.2

Use the expression for the input potential difference V, or otherwise, to determine

(i) the root-mean-square (r.m.s.) potential difference $V_{r.m.s.}$ of the input,

$V_{r.m.s.}$ = ... V [1]

(ii) the number of times per second that the rectified potential difference at the output reaches a peak value.

number = ... [2]

(c) A capacitor is now connected between the terminals AB of the output.
The capacitor reduces the variation (the ripple) in the output to 1.6 V.

(i) On Fig. 11.2, sketch the variation with time t of the smoothed output voltage for time $t = t_1$ to time $t = t_2$. [4]

(ii) Suggest and explain the effect, if any, on the mean power dissipation in resistor R when the capacitor is connected between terminals AB.

....

....

....[2]

[Total: 11]

14 The variation with time t of the sinusoidal current I in a resistor of resistance 450 Ω is shown in Fig. 11.1.

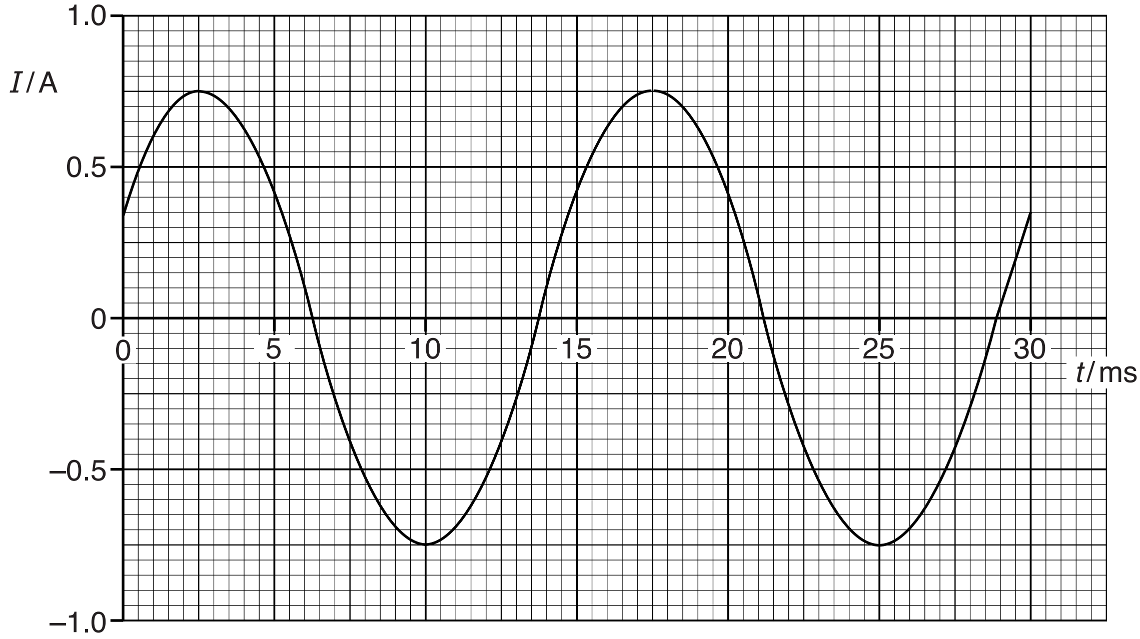

Fig. 11.1

Use data from Fig. 11.1 to determine, for the time t = 0 to t = 30 ms,

(a) the frequency of the current,

frequency = ... Hz [2]

(b) the mean current,

mean current = ... A [1]

(c) the root-mean-square (r.m.s.) current,

r.m.s. current = ... A [2]

(d) the energy dissipated by the resistor.

energy = ... J [2]

[Total: 7]

9702/42/M/J/16

15 A bridge rectifier contains four ideal diodes A, B, C and D, as shown in Fig. 11.1.

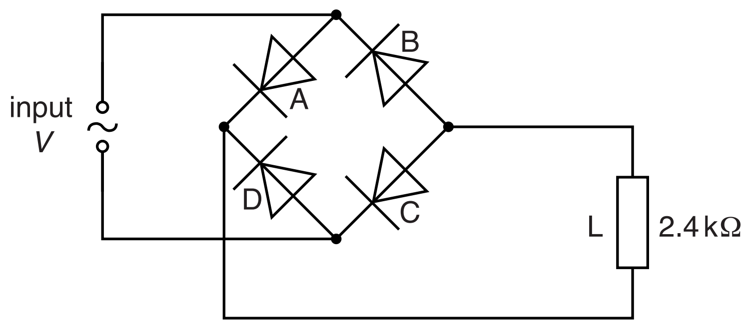

Fig. 11.1

The output of the rectifier is connected to a load L of resistance 2.4 kΩ.

(a) On Fig. 11.1, mark with the letter P the positive terminal of the load. [1]

(b) The variation with time *t* of the potential difference *V* across the input to the rectifier is shown in Fig. 11.2.

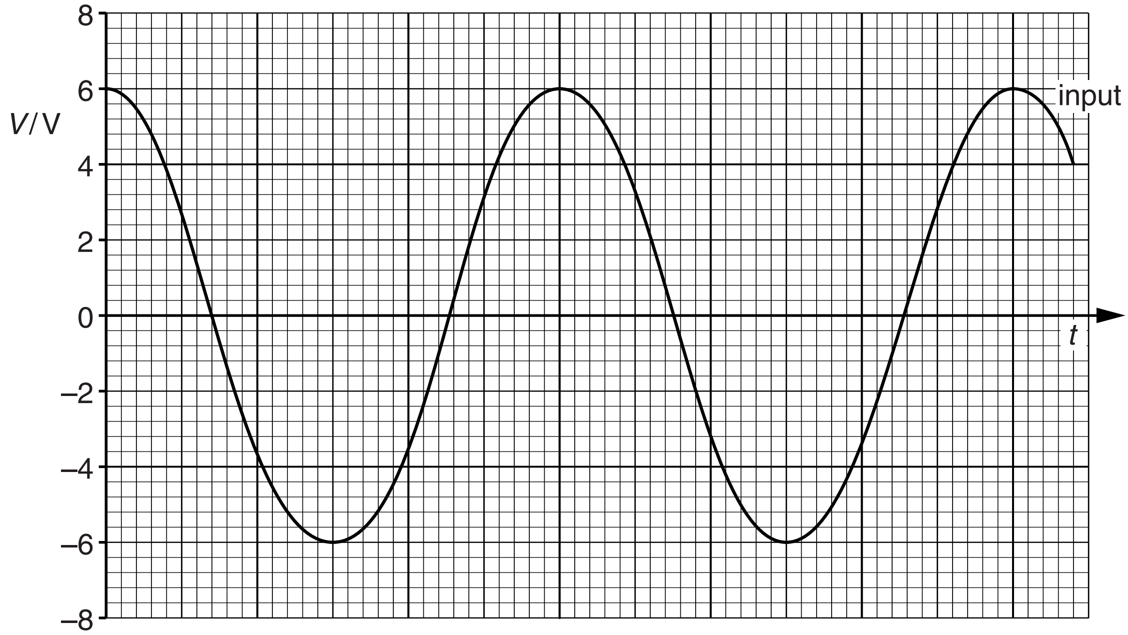

Fig. 11.2

Calculate the root-mean-square (r.m.s.) current in the load L.

r.m.s. current = ... A [2]

(c) The potential difference across the load L is to be smoothed using a capacitor.

(i) On Fig. 11.1, draw the symbol for a capacitor, connected to produce smoothing. [1]

(ii) The minimum potential difference across the load L with the smoothing capacitor connected is 3.0 V.

On Fig. 11.2, sketch the variation with time *t* of the potential difference across the load L. [3]

[Total: 7]

9702/42/O/N/16

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

....

....

....[2]

(b) An alternating current is passed through an air-cored solenoid.
An iron core is inserted into the solenoid and then held stationary within the solenoid. The current in the solenoid is now smaller.

Explain why the root-mean-square (r.m.s.) value of the current in the solenoid is reduced as a result of inserting the core.

....

....

....

....

....[3]

(c) Practical transformers are very efficient. However, there are some power losses.

State two sources of power loss within a transformer.

1. ....

....

2. ....

....
[2]

[Total: 7]