Q1.

5 **(a)** Explain, in terms of heating effect, what is meant by the *root-mean-square (r.m.s.) value* of an alternating current.

....

....

.... [2]

(b) State the relation between the peak current I_0 and the r.m.s. current I_{rms} of a sinusoidally-varying current.

.... [1]

(c) The value of a direct current and the peak value of a sinusoidal alternating current are equal.

(i) Determine the ratio

$$\frac{\text{power dissipation in a resistor of resistance } R \text{ by the direct current}}{\text{power dissipation in the resistor of resistance } R \text{ by the alternating current}}.$$

ratio = ... [2]

(ii) State one advantage and one disadvantage of the use of alternating rather than direct current in the home.

advantage ....

....

disadvantage ....

.... [2]

(d) A current I varies with time t as shown in Fig. 5.1.

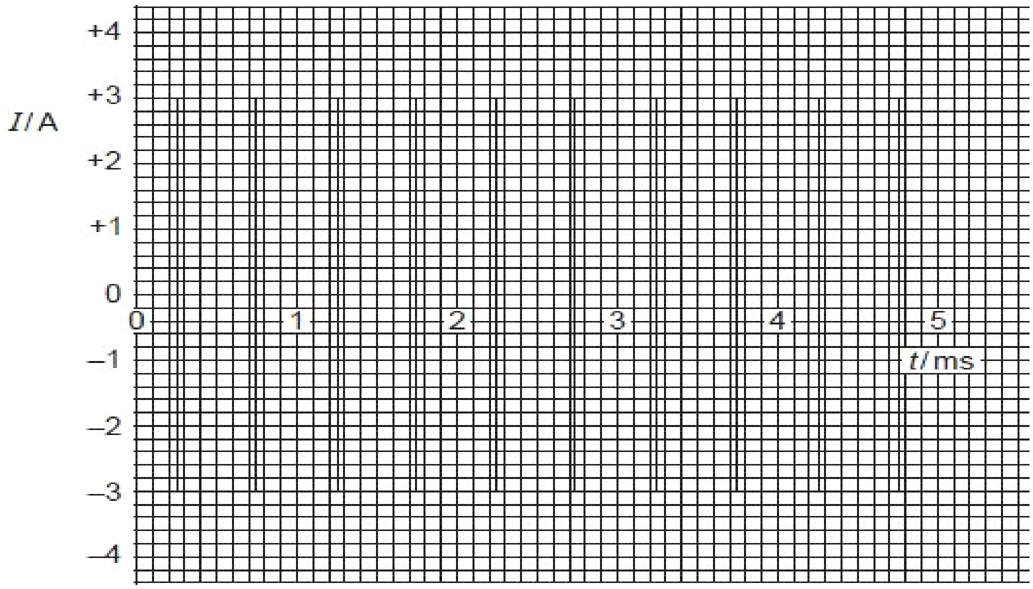


Fig. 5.1

For this varying current, state

(i) the peak value,

peak value = ... A [1]

(ii) the r.m.s. value.

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

Q2.

4 An ideal transformer has 5000 turns on its primary coil. It is to be used to convert a mains supply of 230 V r.m.s. to an alternating voltage having a peak value of 9.0 V.

(a) Calculate the number of turns on the secondary coil.

number = ... [3]

(b) The output from the transformer is to be full-wave rectified. Fig. 4.1 shows part of the rectifier circuit.

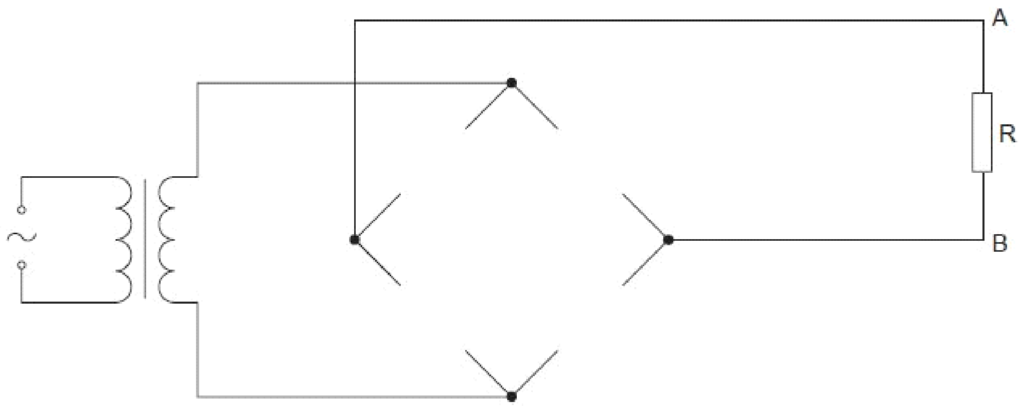


Fig. 4.1

On Fig. 4.1, draw

(i) diode symbols to complete the diagram of the rectifier such that terminal A of the resistor R is positive with respect to terminal B, [2]

(ii) the symbol for a capacitor connected to provide smoothing of the potential difference across the resistor R. [1]

(c) Fig. 4.2 shows the variation with time *t* of the smoothed potential difference *V* across the resistor R.

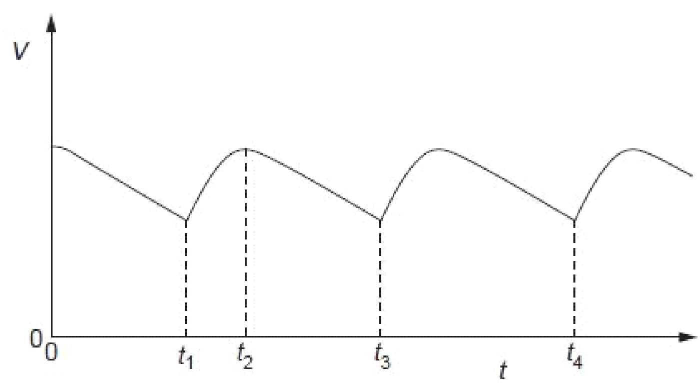


Fig. 4.2

(i) State the interval of time during which the capacitor is being charged from the transformer.

from time .... to time .... [1]

(ii) The resistance of the resistor R is doubled. On Fig. 4.2, sketch the variation with time *t* of the potential difference *V* across the resistor. [2]

Q3.

6 A student is asked to design a circuit by which a direct voltage of peak value 9.0V is obtained from a 240V alternating supply.
The student uses a transformer that may be considered to be ideal and a bridge rectifier incorporating four ideal diodes.
The partially completed circuit diagram is shown in Fig. 6.1.

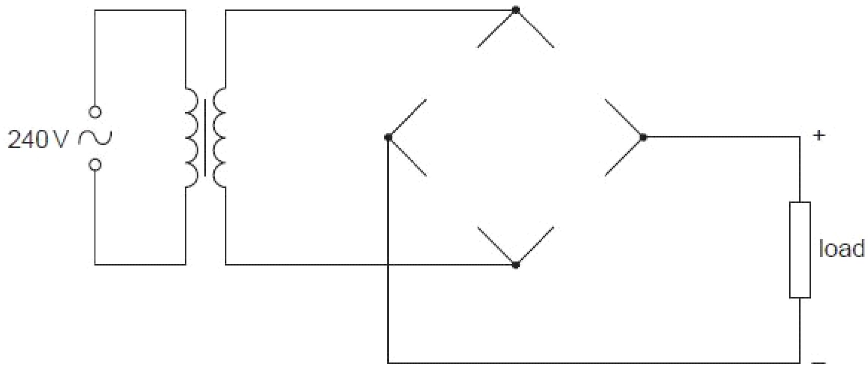


Fig. 6.1

(a) On Fig. 6.1, draw symbols for the four diodes so as to produce the polarity across the load as shown on the diagram. [2]

(b) Calculate the ratio

$$\frac{\text{number of turns on the secondary coil}}{\text{number of turns on the primary coil}}.$$

ratio = ... [3]

Q4.

7 **(a)** Explain what is meant by the *root-mean-square* (r.m.s.) value of an alternating voltage.

For Examiner's Use

....

....

.... [2]

(b) An alternating voltage V is represented by the equation

$$V = 220 \sin(120\pi t),$$

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

For this alternating voltage, determine

(i) the peak voltage,

peak voltage = ... V [1]

(ii) the r.m.s. voltage,

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

(iii) the frequency.

frequency = ... Hz [1]

(c) The alternating voltage in **(b)** is applied across a resistor such that the mean power output from the resistor is 1.5 kW.

Calculate the resistance of the resistor.

resistance = ... Ω [2]

Q5.

6 A transformer is illustrated in Fig. 6.1.

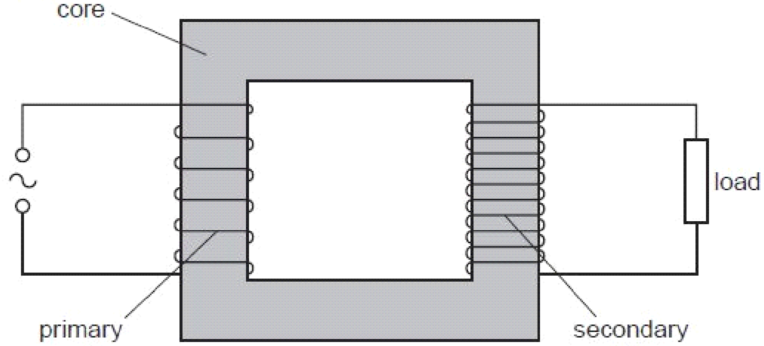


Fig. 6.1

(a) (i) Explain why the coils are wound on a core made of iron.

....

....[1]

(ii) Suggest why thermal energy is generated in the core.

....

....

....[2]

(b) (i) State Faraday's law of electromagnetic induction.

....

....

....[2]

(ii) Use Faraday's law to explain why the potential difference across the load and the e.m.f. of the supply are not in phase.

....

....

....

....[2]

(c) Electrical energy is usually transmitted using alternating current. Suggest why the transmission is achieved using

(i) high voltages,

....

....

.... [2]

(ii) alternating current.

....

.... [1]

Q6.

6 An alternating current supply is connected in series with a resistor R, as shown in Fig. 6.1.

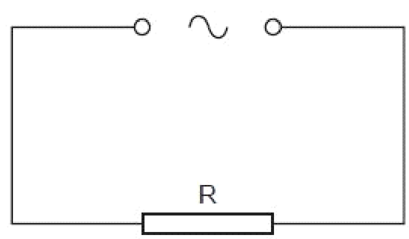


Fig. 6.1

The variation with time t (measured in seconds) of the current I (measured in amps) in the resistor is given by the expression

$$I = 9.9\sin(380t).$$

(a) For the current in the resistor R, determine

(i) the frequency,

frequency = ... Hz [2]

(ii) the r.m.s. current.

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

(b) To prevent over-heating, the mean power dissipated in resistor R must not exceed 400W.
Calculate the minimum resistance of R.

For Examin Use

resistance = ... Ω [2]

Q7.

6 A sinusoidal alternating voltage supply is connected to a bridge rectifier consisting of four ideal diodes. The output of the rectifier is connected to a resistor R and a capacitor C as shown in Fig. 6.1.

For Examin Use

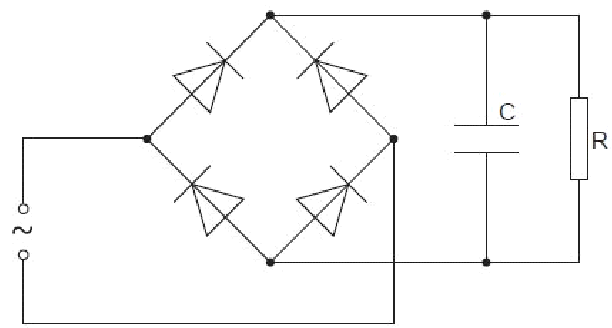
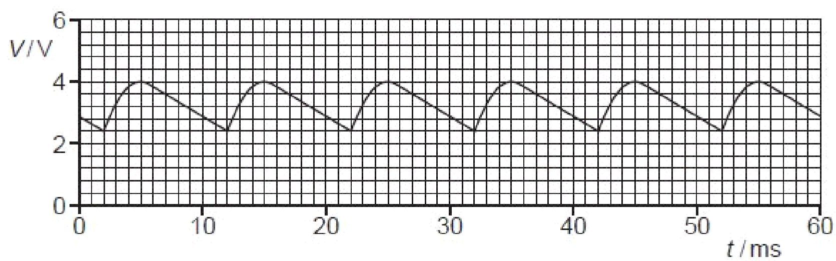


Fig. 6.1

The function of C is to provide some smoothing to the potential difference across R.
The variation with time *t* of the potential difference *V* across the resistor R is shown in Fig. 6.2.



(a) Use Fig. 6.2 to determine, for the alternating supply,

(i) the peak voltage,

peak voltage = ... V [1]

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

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

(iii) the frequency. Show your working.

Ex

frequency = ... Hz [2]

(b) The capacitor C has capacitance 5.0 μF.
For a single discharge of the capacitor through the resistor R, use Fig. 6.2 to

(i) determine the change in potential difference,

change = ... V [1]

(ii) determine the change in charge on each plate of the capacitor,

change = ... C [2]

(iii) show that the average current in the resistor is 1.1×10^{-3} A.

[2]

(c) Use Fig. 6.2 and the value of the current given in **(b)(iii)** to estimate the resistance of resistor R.

resistance = ... Ω [2]

Q8.

6 A simple transformer is illustrated in Fig. 6.1.

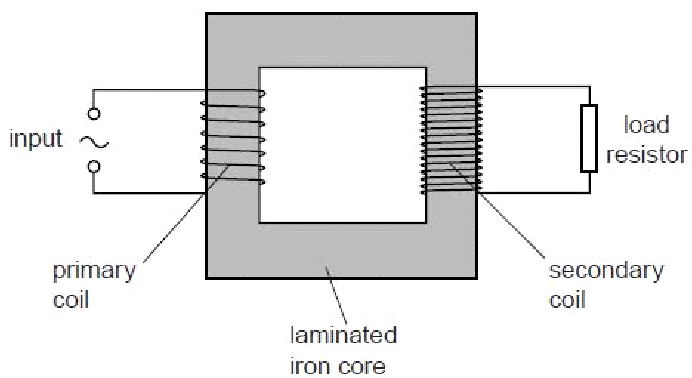


Fig. 6.1

(a) State

(i) why the iron core is laminated,

....

....

....[2]

(ii) what is meant by an *ideal* transformer.

....

.... [1]

(b) An ideal transformer has 300 turns on the primary coil and 8100 turns on the secondary coil.
The root-mean-square input voltage to the primary coil is 9.0 V.

Calculate the peak voltage across the load resistor connected to the secondary coil.

peak voltage = ... V [2]

Q9.

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

For Examiner's Use

....

....

.... [2]

(b) The output of an ideal transformer is connected to a bridge rectifier, as shown in Fig. 6.1.

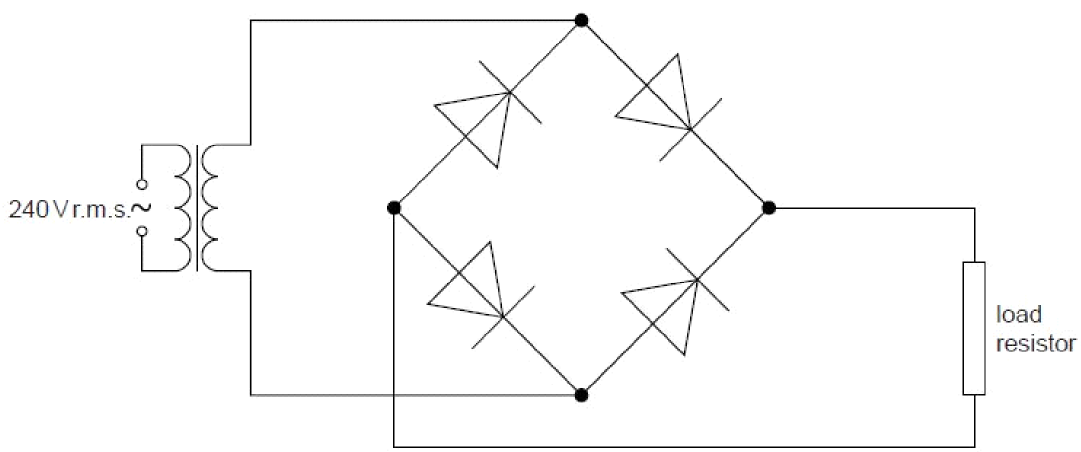


Fig. 6.1

The input to the transformer is 240 V r.m.s. and the **maximum** potential difference across the load resistor is 9.0 V.

(i) On Fig. 6.1, mark with the letter P the positive output from the rectifier. [1]

(ii) Calculate the ratio

$$\frac{\text{number of turns on primary coil}}{\text{number of turns on secondary coil}}.$$

ratio = ... [3]

(c) The variation with time *t* of the potential difference *V* across the load resistor in **(b)** is shown in Fig. 6.2.

For Examiner's Use

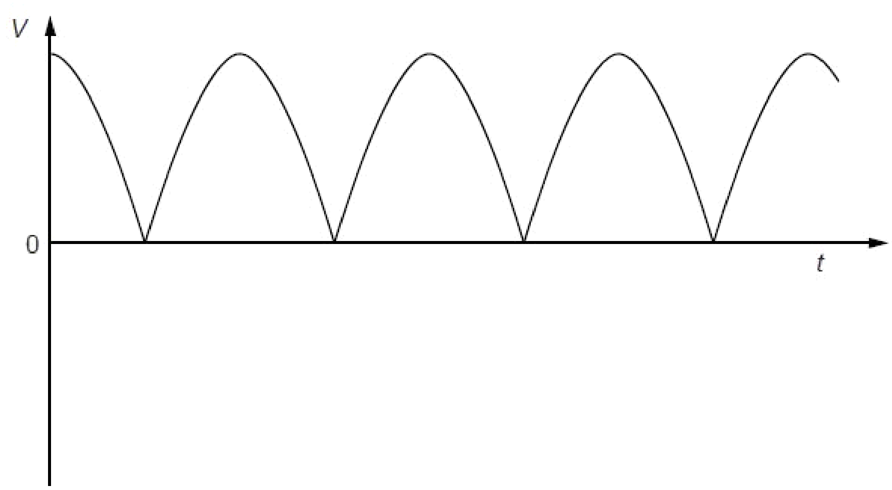


Fig. 6.2

A capacitor is now connected in parallel with the load resistor to produce some smoothing.

(i) Explain what is meant by *smoothing*.

....

.... [1]

(ii) On Fig. 6.2, draw the variation with time t of the smoothed output potential difference. [2]

Q10.

4 The rectified output of a sinusoidal signal generator is connected across a resistor **R** of resistance 1.5 k , as shown in Fig. 4.1.

Fig. 4.1

The variation with time t of the potential difference V across **R** is shown in Fig. 4.2.

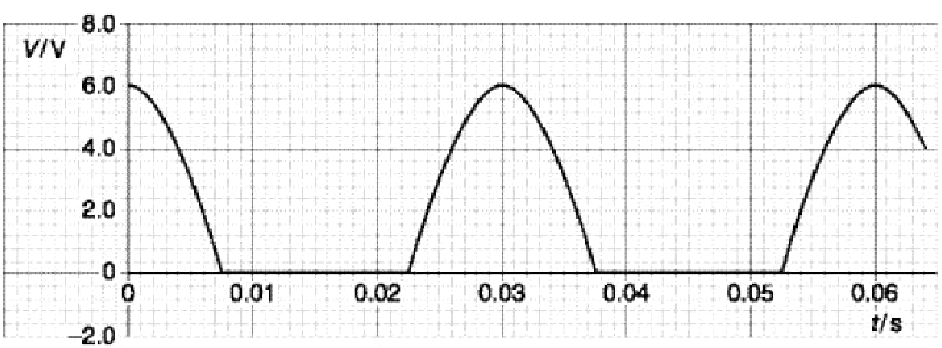


Fig. 4.2

(a) State how the rectification shown in Fig. 4.2 may be achieved.

....

.... [2]

(b) A capacitor is now connected in parallel with the resistor **R**. The resulting variation with time *t* of the potential difference *V* across **R** is shown in Fig. 4.3.

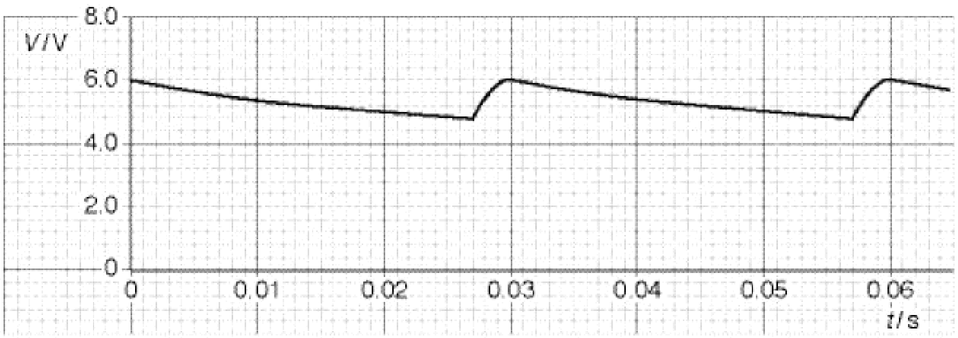


Fig. 4.3

(i) Using Fig. 4.3, determine

1. the mean potential difference across the resistor **R**,

potential difference = ... V

2. the mean current in the resistor,

mean current = ... A

3. the time in each cycle during which the capacitor discharges through the resistor.

time = ... s

[4]

Use

(ii) Using your answers in **(i)**, calculate

1. the charge passing through the resistor during one discharge of the capacitor,

charge = ... C

2. the capacitance of the capacitor.

capacitance = ... F
[4]

(c) A second capacitor is now connected in parallel with the resistor **R** and the first capacitor. On Fig. 4.3, draw a line to show the variation with time *t* of the potential difference *V* across the resistor. [1]

Q11.

6 An alternating supply of frequency 50 Hz and having an output of 6.0 V r.m.s. is to be rectified so as to provide direct current for a resistor R. The circuit of Fig. 6.1 is used.

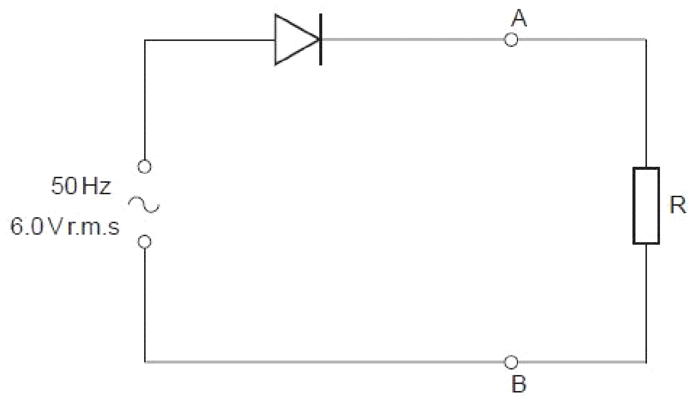


Fig. 6.1

The diode is ideal. The Y-plates of a cathode-ray oscilloscope (c.r.o.) are connected between points A and B.

(a) **(i)** Calculate the maximum potential difference across the diode during one cycle.

potential difference = ... V [2]

(ii) State the potential difference across R when the diode has maximum potential difference across it. Give a reason for your answer.

....

.... [1]

(b) The Y-plate sensitivity of the c.r.o. is set at 2.0 V cm^{-1} and the time-base at 5.0 ms cm^{-1}.

On Fig. 6.2, draw the waveform that is seen on the screen of the c.r.o. [3]

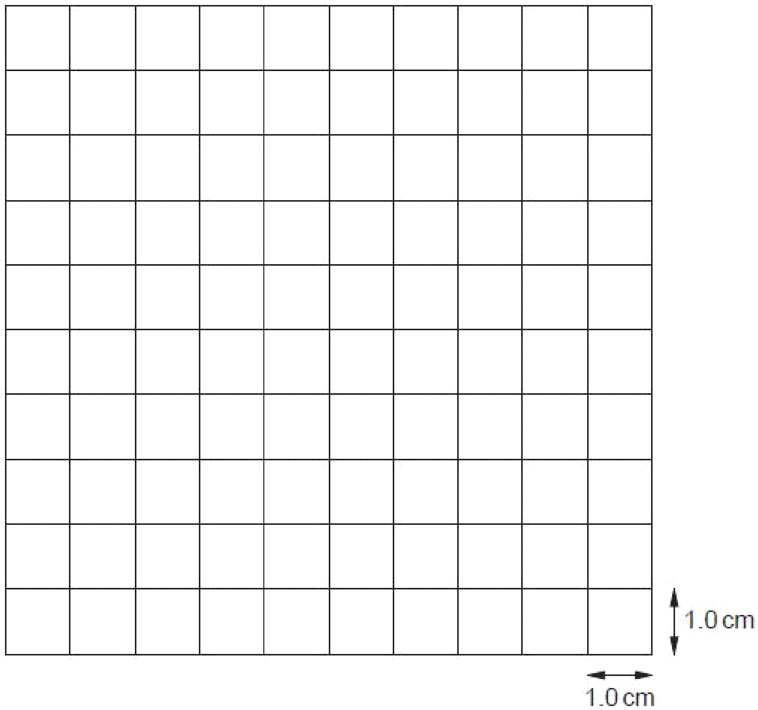


Fig. 6.2

(c) A capacitor of capacitance 180 μF is connected into the circuit to provide smoothing of the potential difference across the resistor R.

(i) On Fig. 6.1, show the position of the capacitor in the circuit. [1]

(ii) Calculate the energy stored in the fully-charged capacitor.

energy = ... J [3]

(iii) During discharge, the potential difference across the capacitor falls to $0.43\,V_0$, where V_0 is the maximum potential difference across the capacitor.

Calculate the fraction of the total energy that remains in the capacitor after the discharge.

fraction = ... [2]

Q12.

6 A simple iron-cored transformer is illustrated in Fig. 6.1.

For Examiner's Use

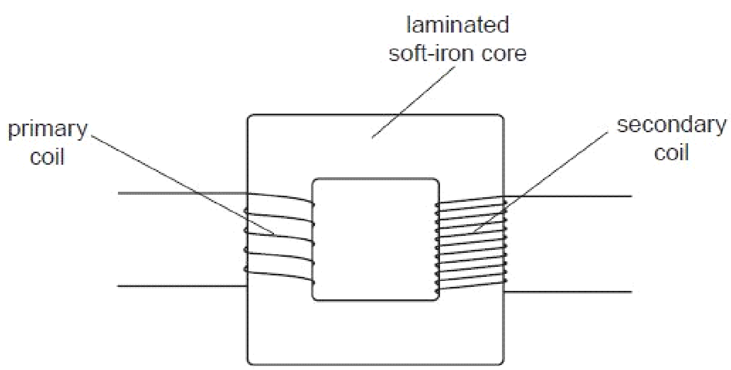


Fig. 6.1

(a) Suggest why the core is

(i) a continuous loop,

....

.... [1]

(ii) laminated.

....

....

.... [2]

(b) (i) State Faraday's law of electromagnetic induction.

....

....

.... [2]

(ii) Use Faraday's law to explain the operation of the transformer.

....

....

....

.... [3]

(c) State two advantages of the use of alternating voltages for the transmission and use of electrical energy.

1. ....

....

2. ....

....

[2]

Fo Exami Us

Q13.

7 A sinusoidal alternating voltage is to be rectified.

For Examiner's Use

(a) Suggest one advantage of full-wave rectification as compared with half-wave rectification.

....

.... [1]

(b) The rectification is produced using the circuit of Fig. 7.1.

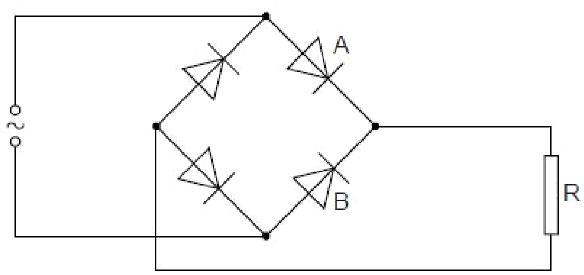


Fig. 7.1

All the diodes may be considered to be ideal.

The variation with time *t* of the alternating voltage applied to the circuit is shown in Fig. 7.2 and in Fig. 7.3.

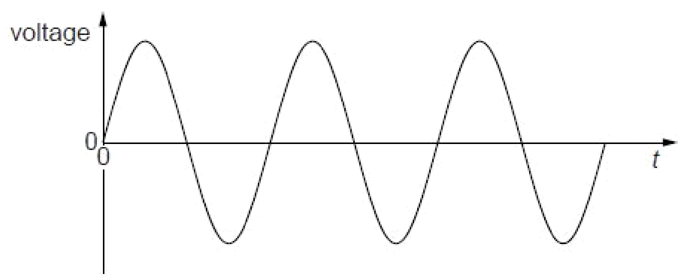


Fig. 7.2

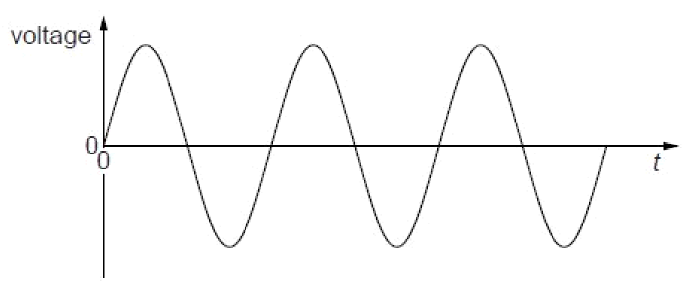


Fig. 7.3

(i) On the axes of Fig. 7.2, draw a graph to show the variation with time *t* of the potential difference across diode A. [1]

(ii) On the axes of Fig. 7.3, draw a graph to show the variation with time *t* of the potential difference across diode B. [1]

(c) **(i)** On Fig. 7.1, draw the symbol for a capacitor, connected into the circuit so as to provide smoothing. [1]

(ii) Fig. 7.4 shows the variation with time *t* of the smoothed potential difference across the resistor R in Fig. 7.1.

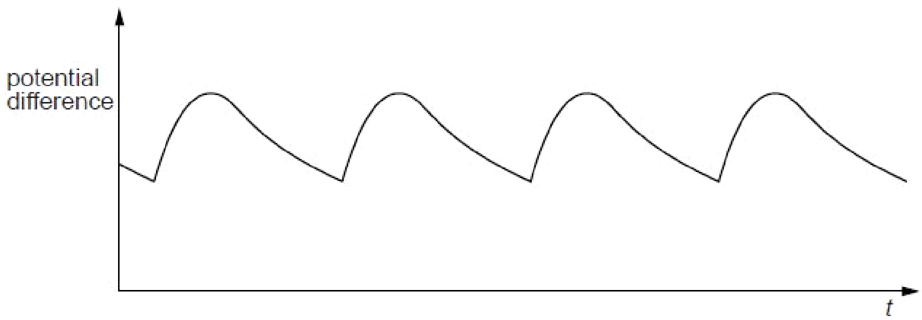


Fig. 7.4

1. State how the amount of smoothing may be increased.

....

.... [1]

2. On Fig. 7.4, draw the variation with time *t* of the potential difference across resistor R for increased smoothing. [2]

Q14.

6 A simple iron-cored transformer is illustrated in Fig. 6.1.

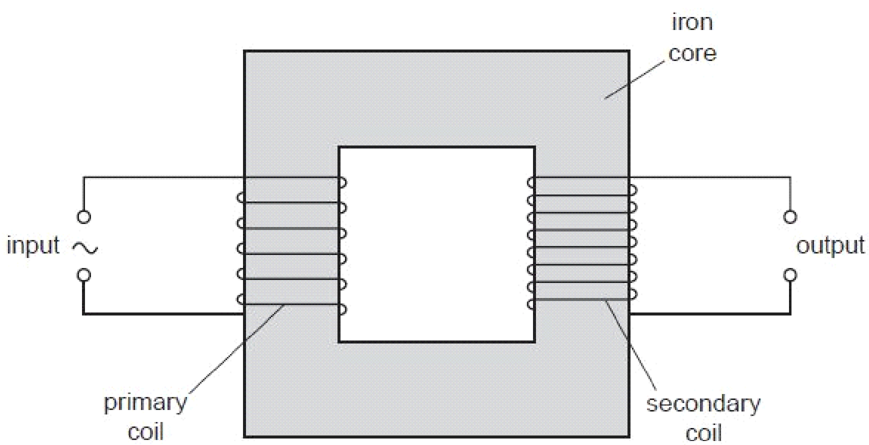


Fig. 6.1

(a) **(i)** State why the primary and secondary coils are wound on a core made of iron.

....

....

....[1]

(ii) Suggest why thermal energy is generated in the core when the transformer is in use.

....

....

....

....[3]

(b) The root-mean-square (r.m.s.) voltage and current in the primary coil are V_P and I_P respectively.
The r.m.s. voltage and current in the secondary coil are V_S and I_S respectively.

For Examiner's Use

(i) Explain, by reference to direct current, what is meant by the *root-mean-square* value of an alternating current.

....

....

.... [2]

(ii) Show that, for an ideal transformer,

$$\frac{V_S}{V_P} = \frac{I_P}{I_S}.$$

[2]

Q15.

6 The variation with time t of the current I in a resistor is shown in Fig. 6.1.

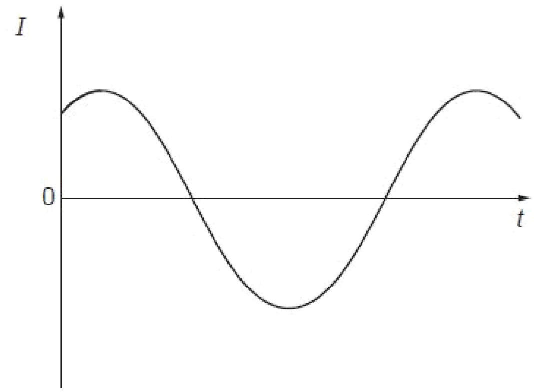


Fig. 6.1

The variation of the current with time is sinusoidal.

(a) Explain why, although the current is not in one direction only, power is converted in the resistor.

....

....

.... [2]

(b) Using the relation between root-mean-square (r.m.s.) current and peak current, deduce the value of the ratio

$$\frac{\text{average power converted in the resistor}}{\text{maximum power converted in the resistor}}.$$

ratio = ... [3]

Q16.

6 The variation with time t of the output V of an alternating voltage supply of frequency 50 Hz is shown in Fig. 6.1.

For Examiner's Use

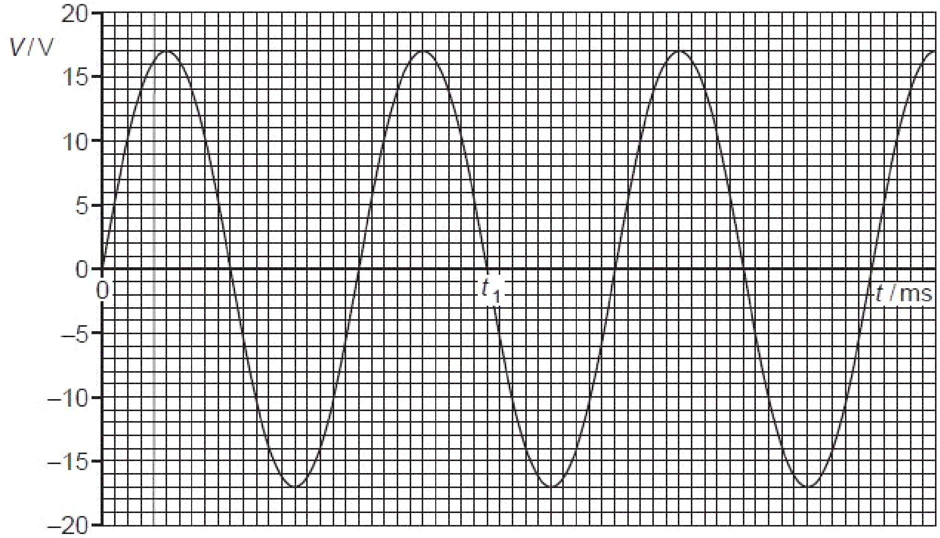


Fig. 6.1

(a) Use Fig. 6.1 to state

(i) the time t_1,

t_1 = ... s [2]

(ii) the peak value V_0 of the voltage,

V_0 = ... V [1]

(iii) the root-mean-square voltage V_{rms},

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

(iv) the mean voltage $\langle V \rangle$.

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

(b) The alternating supply is connected in series with a resistor of resistance 2.4 Ω. Calculate the mean power dissipated in the resistor.

For Examiner's Use

power = ... W [2]

Q17.

5 The components for a bridge rectifier are shown in Fig. 5.1.

For Examiner's Use

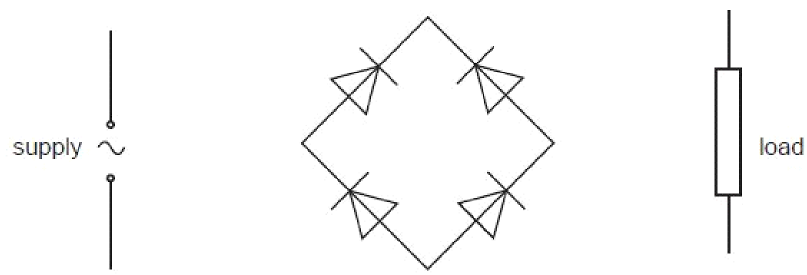


Fig. 5.1

(a) Complete the circuit of Fig. 5.1 by showing the connections of the supply and of the load to the diodes. [2]

(b) Suggest one advantage of the use of a bridge rectifier, rather than a single diode, for the rectification of alternating current.

....

.... [1]

(c) State

(i) what is meant by *smoothing*,

....

.... [1]

(ii) the effect of the value of the capacitance of the smoothing capacitor in relation to smoothing.

....

....

.... [2]

Q18.

6 A bridge rectifier consists of four ideal diodes A, B, C and D, connected as shown in Fig. 6.1.

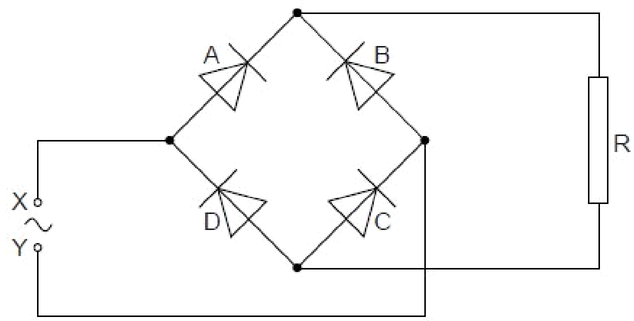


Fig. 6.1

An alternating supply is applied between the terminals X and Y.

(a) **(i)** On Fig. 6.1, label the positive (+) connection to the load resistor R. [1]

(ii) State which diodes are conducting when terminal Y of the supply is positive.

diode .... and diode ....[1]

Q19.

(b) The variation with time *t* of the potential difference *V* across the load resistor R is shown in Fig. 6.2.

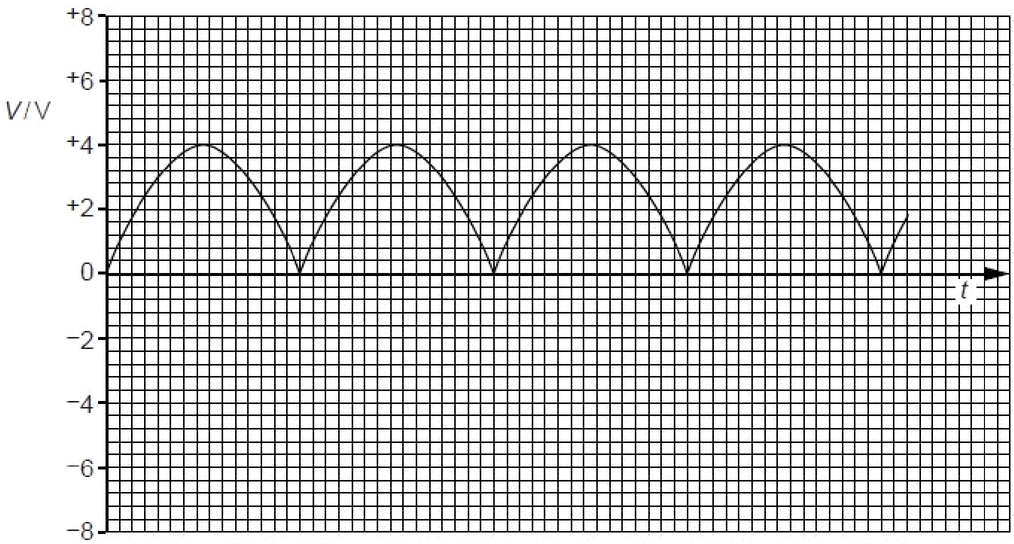


Fig. 6.2

The load resistor R has resistance 2700 Ω.

For Examiner's Use

(i) Use Fig. 6.2 to determine the mean power dissipated in the resistor R.

power = ... W [3]

(ii) On Fig. 6.1, draw the symbol for a capacitor, connected so as to increase the mean power dissipated in the resistor R. [1]

(c) The capacitor in **(b)(ii)** is now removed from the circuit.
The diode A in Fig. 6.1 stops functioning, so that it now has infinite resistance.

On Fig. 6.2, draw the variation with time *t* of the new potential difference across the resistor R. [2]

Q19.

7 (a) The mean value of an alternating current is zero.

Explain

(i) why an alternating current gives rise to a heating effect in a resistor,

....

....

.... [2]

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

....

....

....

.... [2]

(b) A simple iron-cored transformer is illustrated in Fig. 7.1.

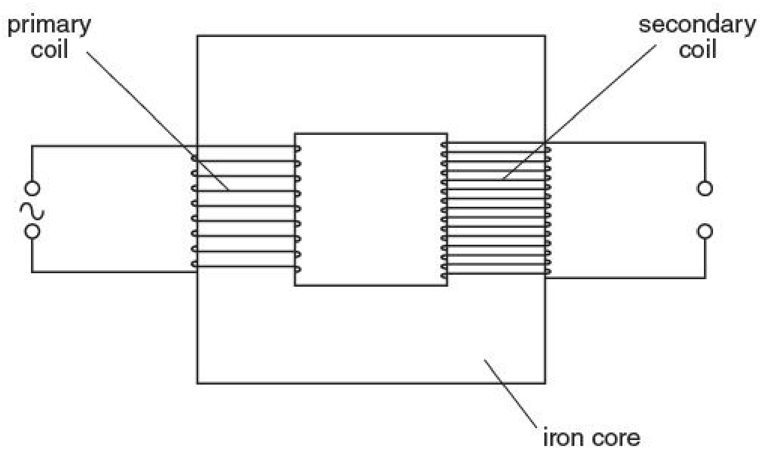


Fig. 7.1

(i) State Faraday's law of electromagnetic induction.

....

....

.... [2]

(ii) Use Faraday's law to explain why the current in the primary coil is not in phase with the e.m.f. induced in the secondary coil.

....

....

....

....

.... [3]