Cambridge International AS & A Level

PHYSICS

Paper 4

Topical Past Paper Questions
+ Answer Scheme

2016 - 2021

Chapter 14

Alternating currents

316. 9702_s21_qp_42 Q: 10

(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.

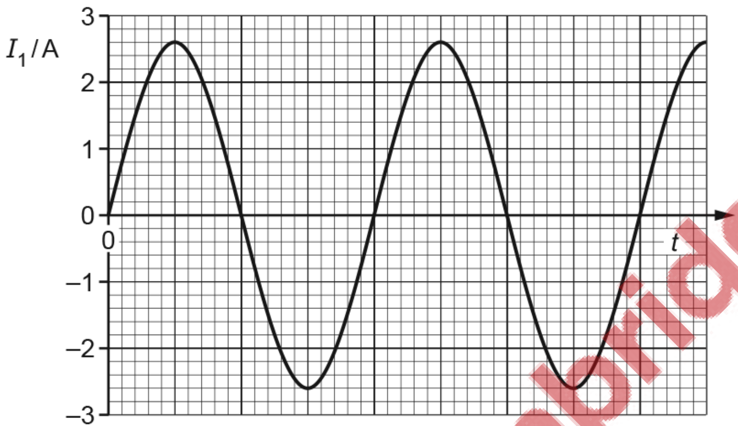

Fig. 10.1

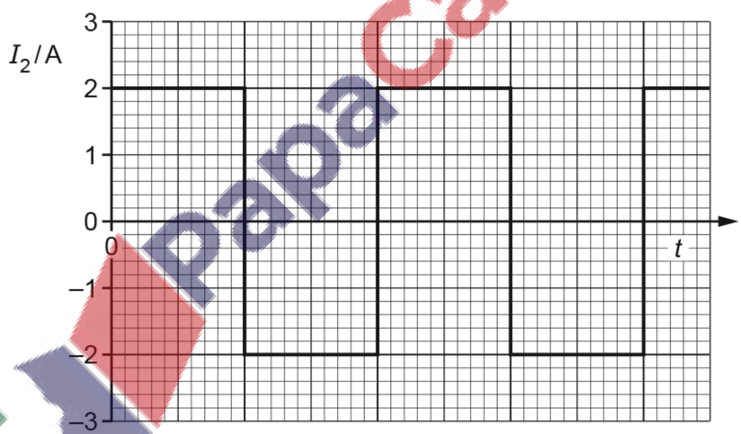

Fig. 10.2

(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]

317. 9702_w21_qp_41 Q: 9

(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.

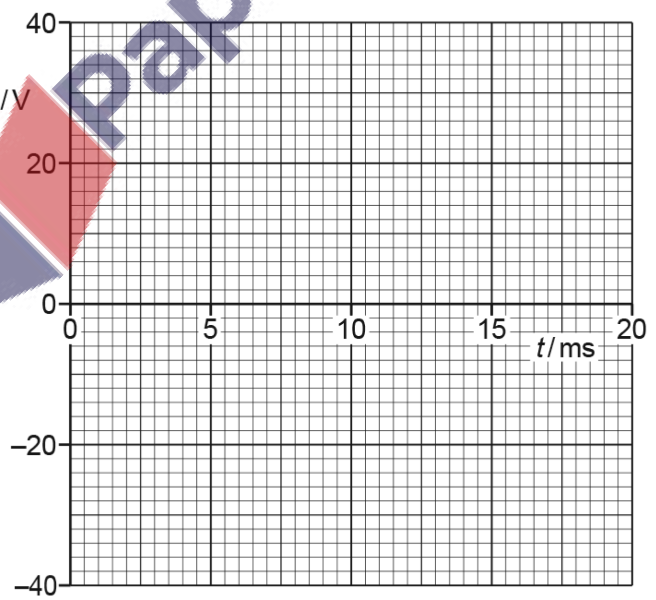

Fig. 9.1

[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]

318. 9702_w21_qp_43 Q: 9

(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.

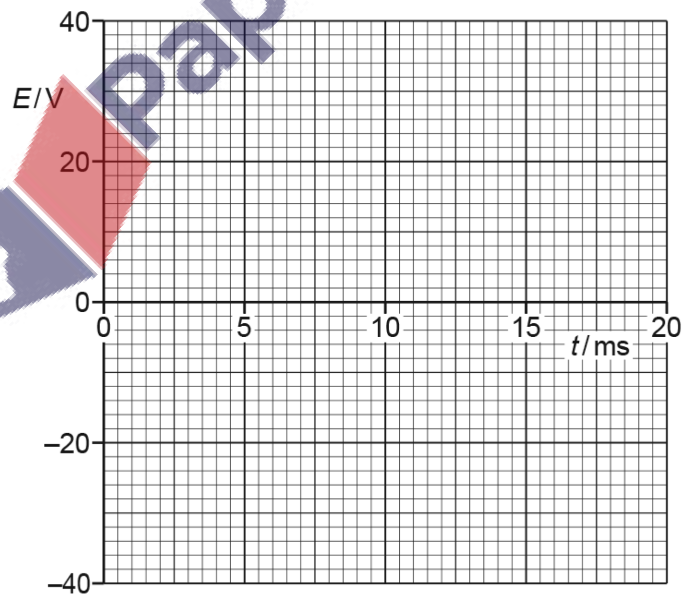

Fig. 9.1

[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]

319. 9702_m19_qp_42 Q: 8

A horseshoe magnet is placed on a top pan balance. A rigid copper wire is fixed between the poles of the magnet, as illustrated in Fig. 8.1.

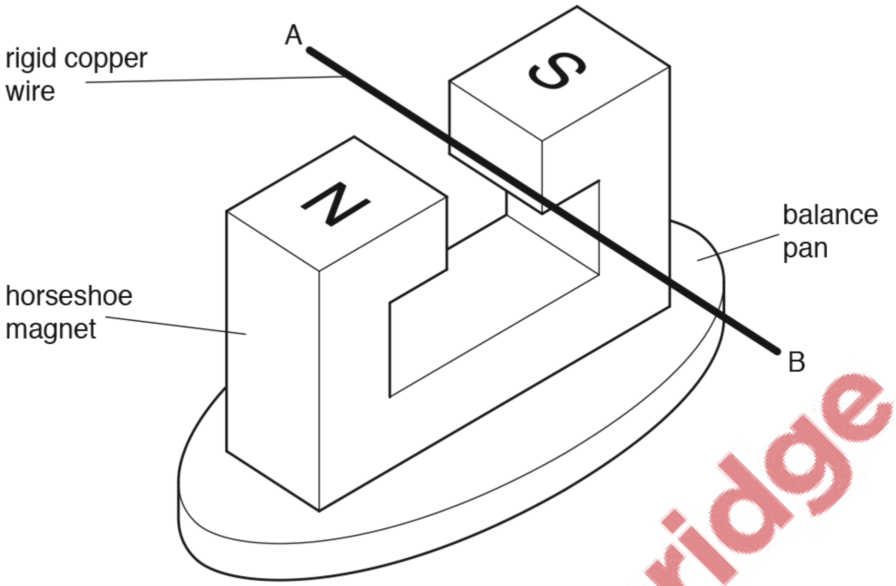

Fig. 8.1

The wire is clamped at ends A and B.

(a) When a direct current is switched on in the wire, the reading on the balance is seen to **decrease**.

State and explain the direction of:

(i) the force acting on the wire

....

....

....

.... [3]

(ii) the current in the wire.

....

....

.... [2]

(b) A direct current of 4.6A in the wire causes the reading on the balance to change by 4.5×10^{-3} N.

The direct current is now replaced by an alternating current of frequency 40 Hz and root-mean-square (r.m.s.) value 4.6 A.

On the axes of Fig. 8.2, sketch a graph to show the change in balance reading over a time of 50 ms.

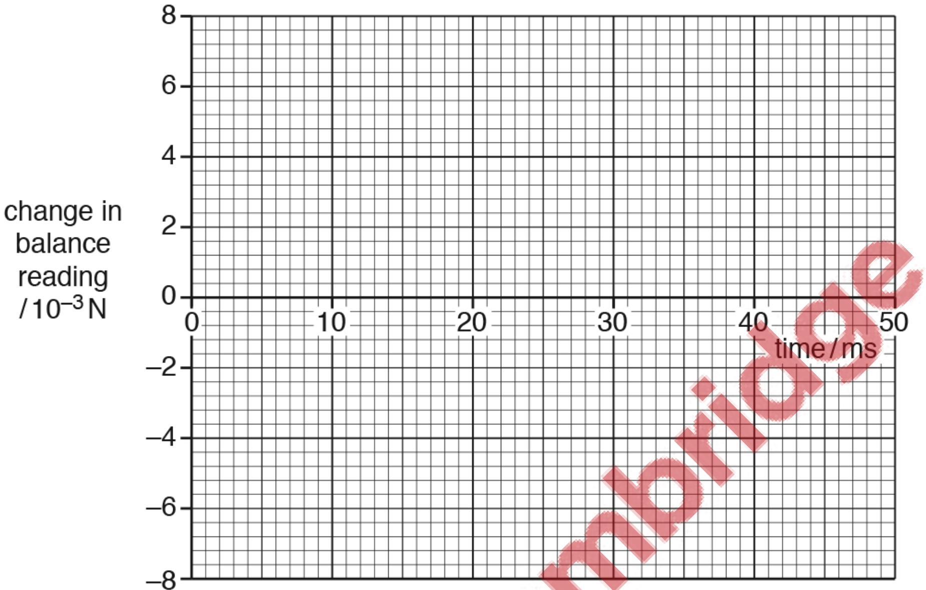

Fig. 8.2

[3]

[Total: 8]

320. 9702_w19_qp_42 Q: 11

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

....

....

.... [2]

(b) A solenoid S has a small coil C placed near to one of its ends, as shown in Fig. 11.1.

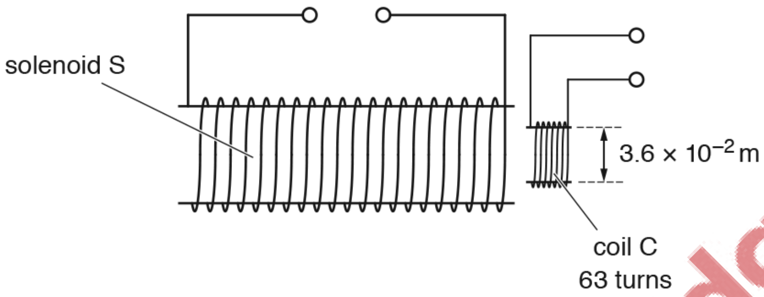

Fig. 11.1

The coil C has a circular cross-section of diameter 3.6×10^{-2} m and contains 63 turns of wire.

The solenoid S produces a uniform magnetic field of flux density *B*, in tesla, in the region of coil C given by the expression

$$B = 9.4 \times 10^{-4} I$$

where I is the current, in ampere, in the solenoid S.

The variation with time *t* of the current I in solenoid S is shown in Fig. 11.2.

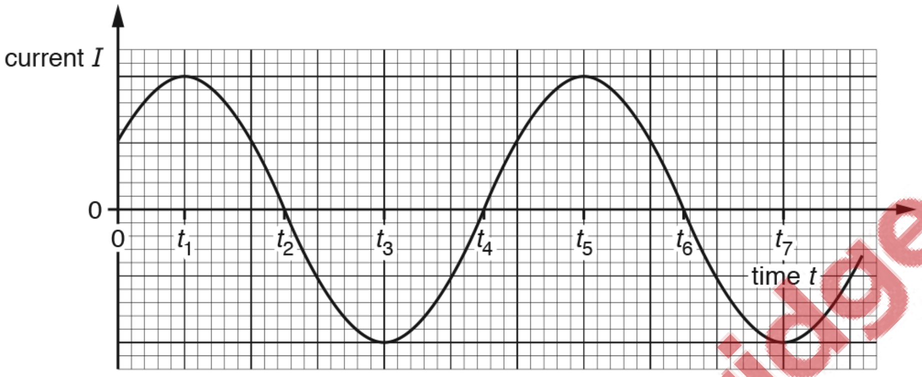

Fig. 11.2

State two times at which:

(i) there is no electromotive force (e.m.f.) induced in coil C

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

(ii) the induced e.m.f. in coil C is a maximum but with opposite polarities.

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

(c) The alternating current in the solenoid S in **(b)** is replaced by a constant current of 5.0 A.

Calculate the average e.m.f. induced in coil C when the current in solenoid S is reversed in a time of 6.0 ms.

e.m.f. induced = ... V [3]

[Total: 7]

321. 9702_w17_qp_41 Q: 10

(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]

322. 9702_w17_qp_43 Q: 10

(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]

323. 9702_m16_qp_42 Q: 3

(a) Define *specific heat capacity*.

....

....

....[2]

(b) A student carries out an experiment to determine the specific heat capacity of a liquid using the apparatus illustrated in Fig. 3.1.

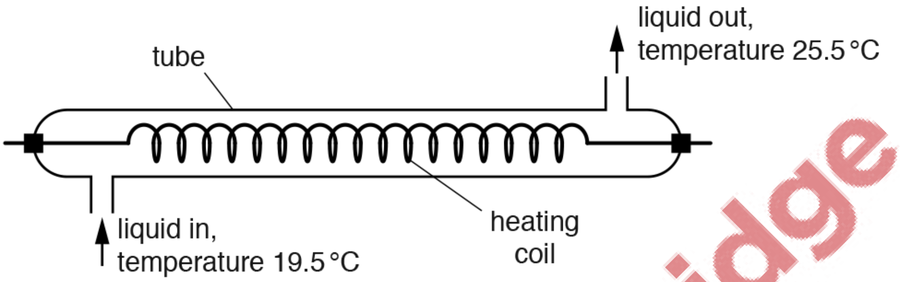

Fig. 3.1

Liquid enters the tube at a constant temperature of 19.5 °C and leaves the tube at a temperature of 25.5 °C. The mass of liquid flowing through the tube per unit time is *m*. Electrical power *P* is dissipated in the heating coil.

The student changes *m* and adjusts *P* until the final temperature of the liquid leaving the tube is 25.5 °C.

The data shown in Fig. 3.2 are obtained.

$m / \mathrm{g\,s^{-1}}$	P / W
1.11	33.3
1.58	44.9

Fig. 3.2

(i) Suggest why the student obtains data for two values of *m*, rather than for one value.

....

....[1]

(ii) Calculate the specific heat capacity of the liquid.

Show your working.

specific heat capacity = ... $J\,kg^{-1}\,K^{-1}$ [3]

(c) When the heating coil in **(b)** dissipates 33.3W of power, the potential difference V across the coil is given by the expression

$$V = 27.0 \sin(395t).$$

The potential difference is measured in volts and the time t is measured in seconds.

Determine the resistance of the coil.

resistance = ... Ω [3]

[Total: 9]

324. 9702_w21_qp_42 Q: 10

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.

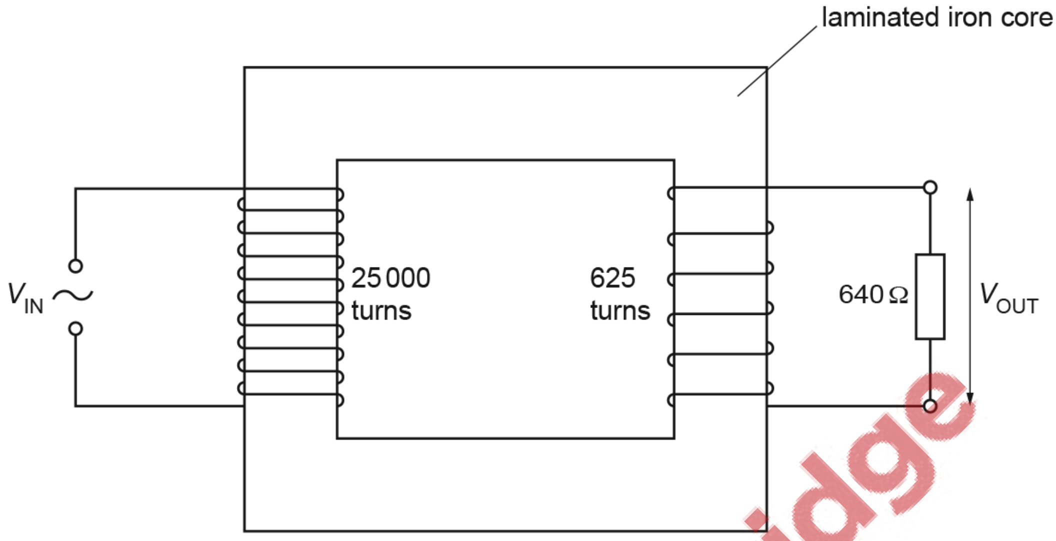

Fig. 10.1

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.

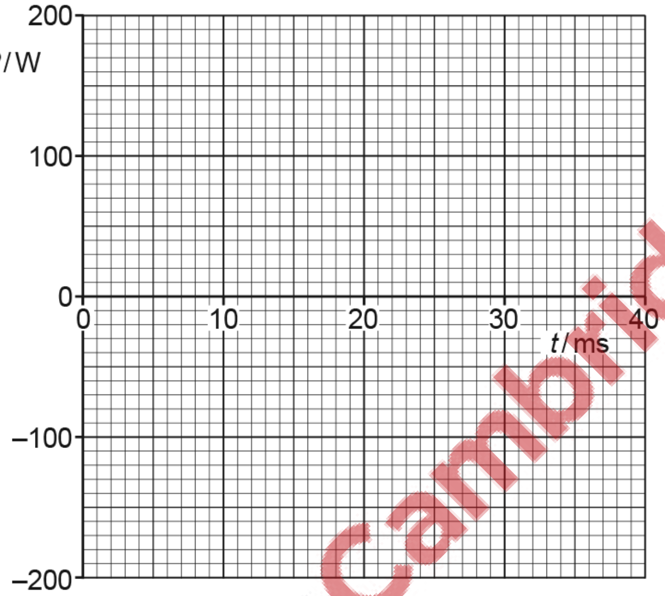

Fig. 10.2

[3]

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

....

....

....

.... [2]

[Total: 10]

325. 9702_m20_qp_42 Q: 9

(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.

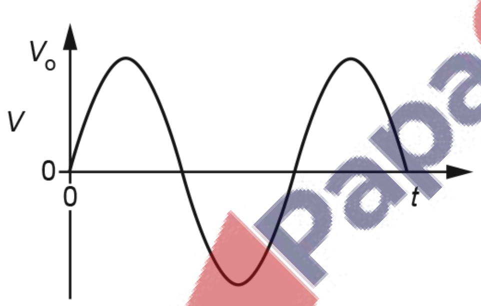

Fig. 9.1

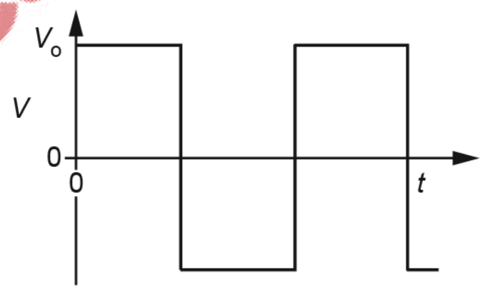

Fig. 9.2

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]

326. 9702_s20_qp_42 Q: 10

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

....

....

.... [2]

(b) A simple iron-cored transformer is illustrated in Fig. 10.1.

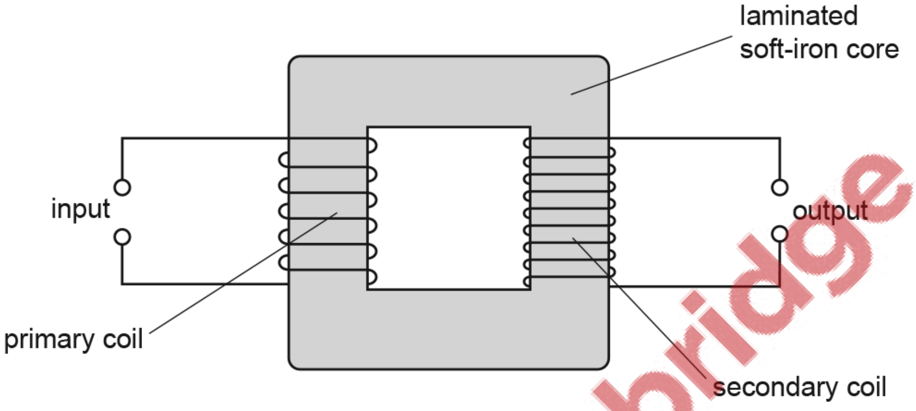

Fig. 10.1

(i) State **one** function of a transformer.

....

.... [1]

(ii) A sinusoidal alternating current in the primary coil gives rise to a varying magnetic flux linking the secondary coil.

Use Faraday's law to explain why the output from the transformer is an electromotive force (e.m.f.) that is alternating.

....

....

....

....

.... [3]

(iii) State why the soft-iron core of the transformer is laminated.

....

.... [1]

[Total: 7]

327. 9702_s19_qp_42 Q: 10

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

....

....

....[2]

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

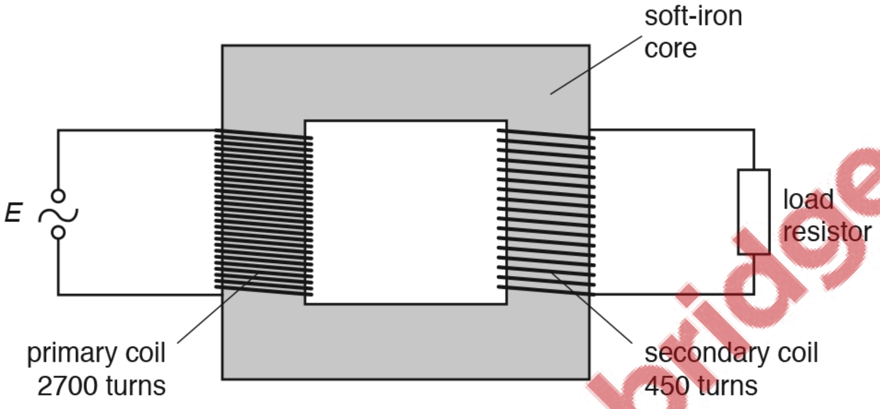

Fig. 10.1

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]

328. 9702_m17_qp_42 Q: 9

An ideal transformer is shown in Fig. 9.1.

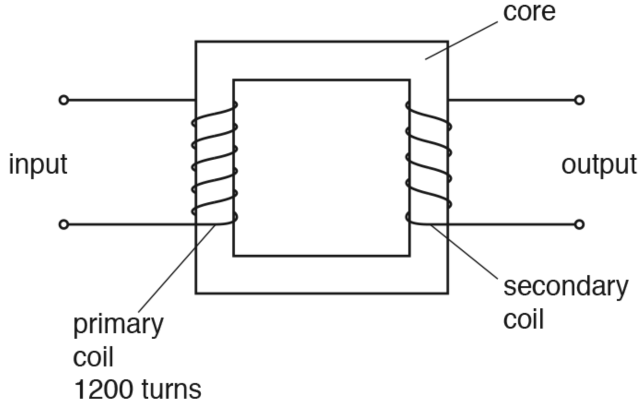

Fig. 9.1

(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.

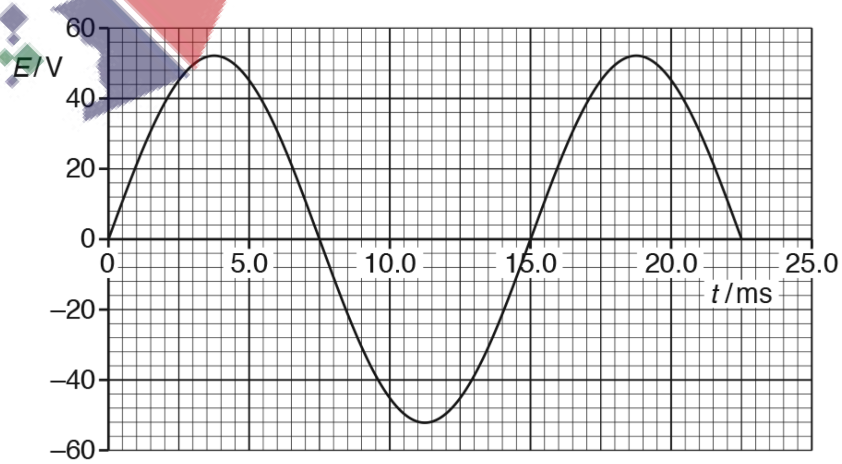

Fig. 9.2

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.

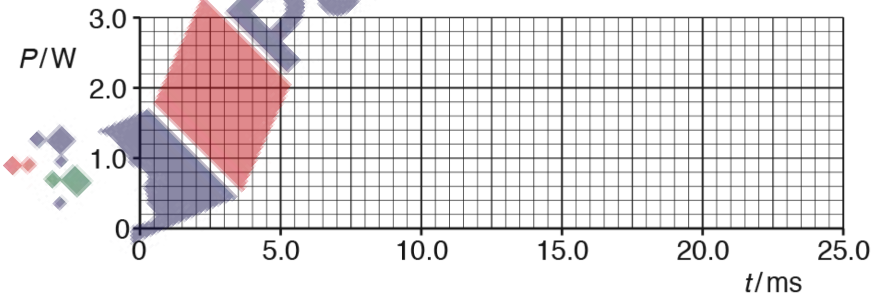

Fig. 9.3

[3]

[Total: 11]

329. 9702_s17_qp_41 Q: 9

A simple transformer is illustrated in Fig. 9.1.

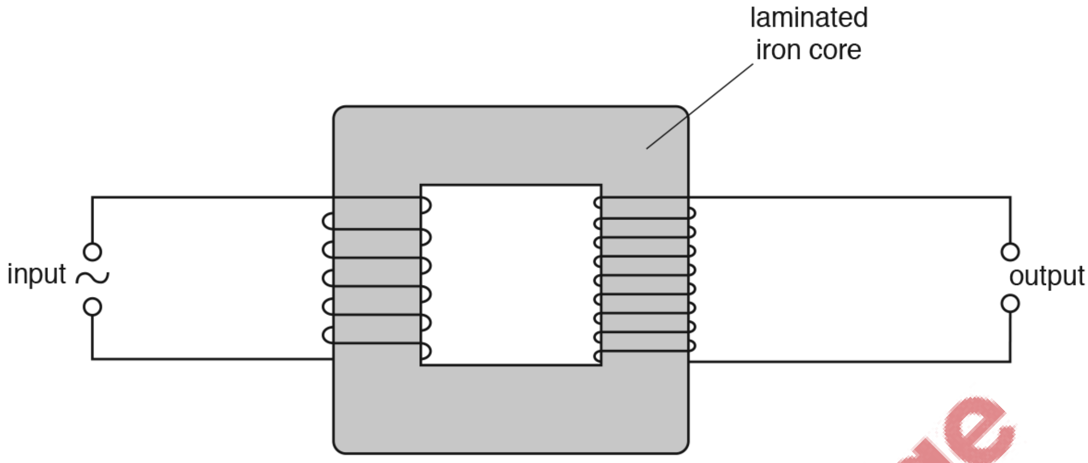

Fig. 9.1

(a) **(i)** State why the transformer has an iron core, rather than having no core.

....

....[1]

(ii) Explain why the core is laminated.

....

....

....[2]

(b) By reference to the action of a transformer, explain why the input to the transformer is an alternating voltage, rather than a constant voltage.

....

....

....

....

....[3]

[Total: 6]

330. 9702_s17_qp_43 Q: 9

A simple transformer is illustrated in Fig. 9.1.

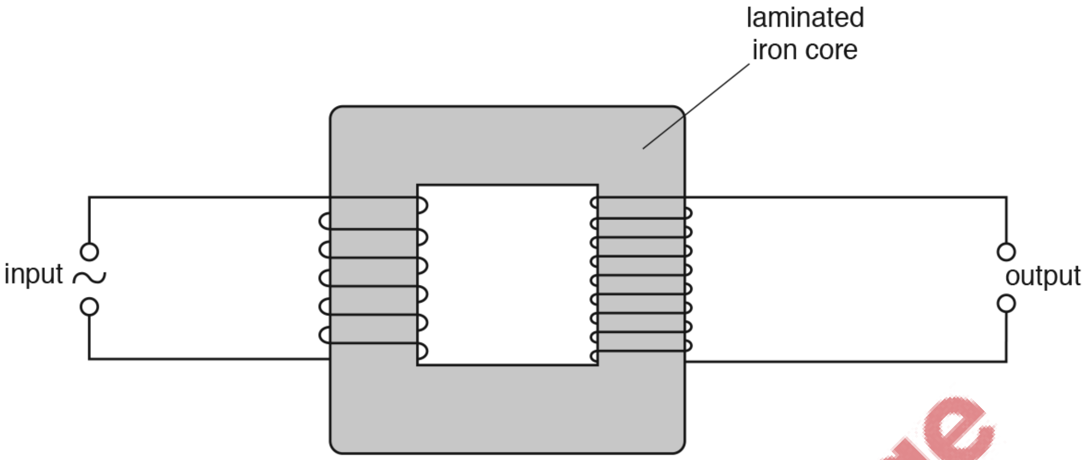

Fig. 9.1

(a) **(i)** State why the transformer has an iron core, rather than having no core.

....

....[1]

(ii) Explain why the core is laminated.

....

....

....[2]

(b) By reference to the action of a transformer, explain why the input to the transformer is an alternating voltage, rather than a constant voltage.

....

....

....

....

....[3]

[Total: 6]

331. 9702_w16_qp_42 Q: 11

(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]

332. 9702_m21_qp_42 Q: 10

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.

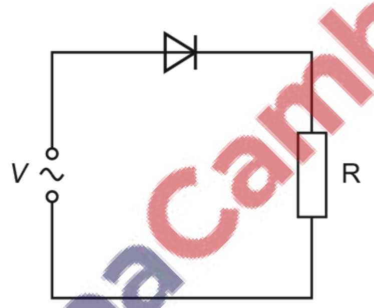

Fig. 10.1

(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.

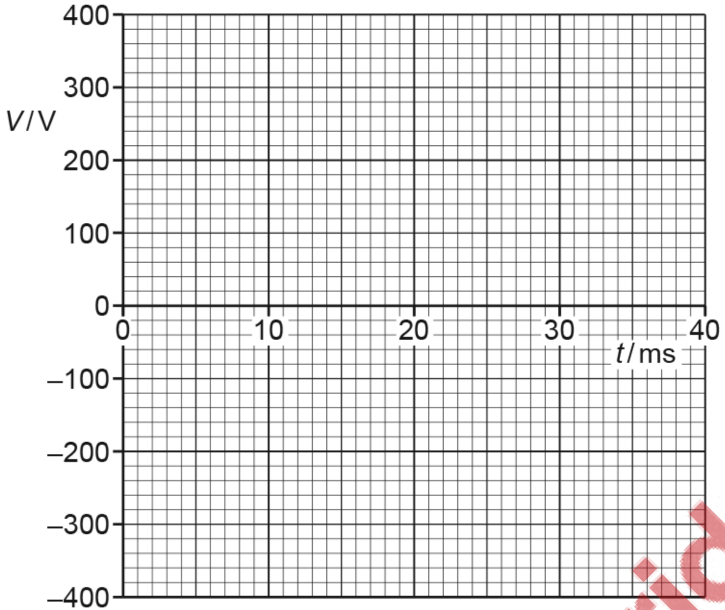

Fig. 10.2

[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]

333. 9702_s19_qp_41 Q: 10

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

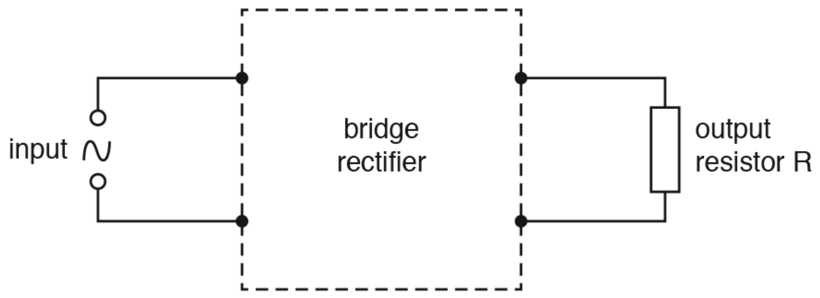

Fig. 10.1

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.

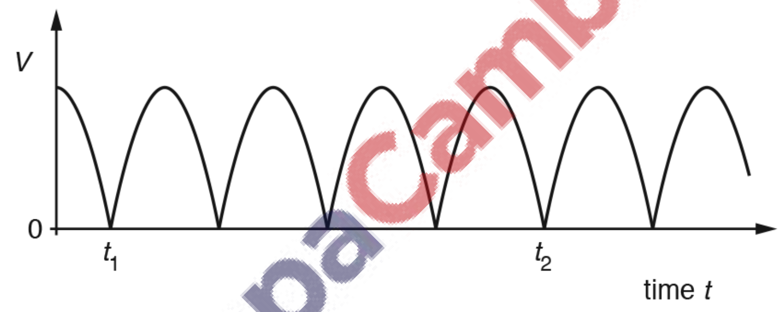

Fig. 10.2

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]

334. 9702_s19_qp_43 Q: 10

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

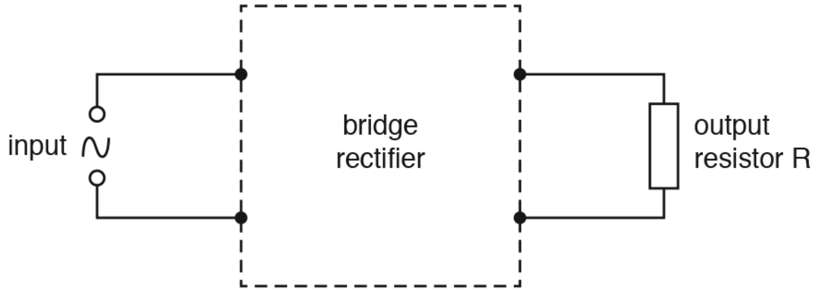

Fig. 10.1

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.

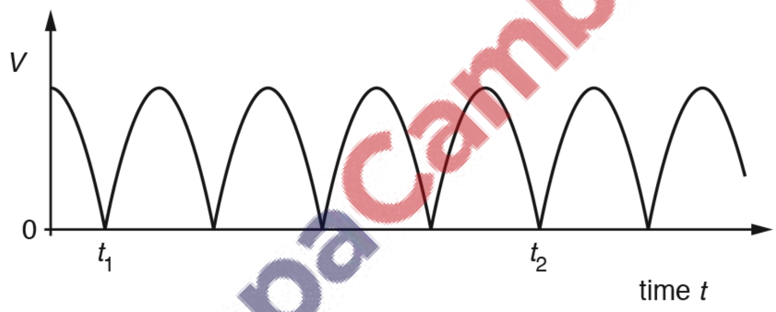

Fig. 10.2

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]

335. 9702_w19_qp_41 Q: 10

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

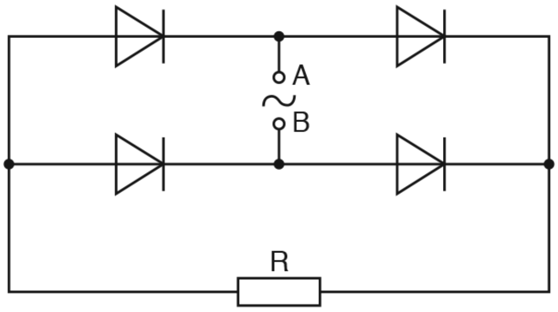

Fig. 10.1

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.

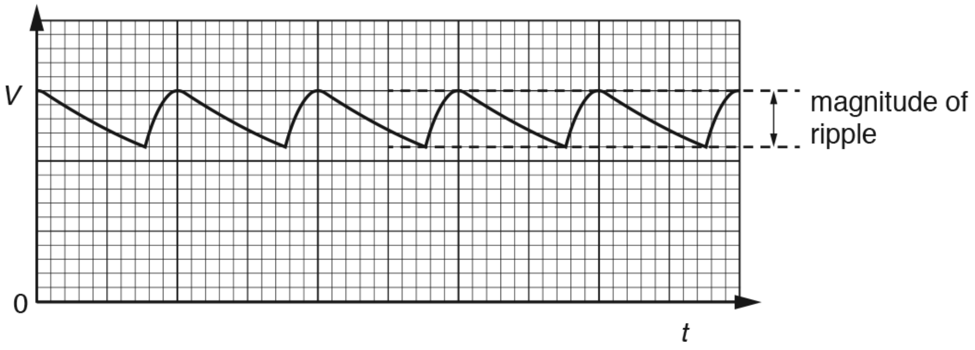

Fig. 10.2

(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]

336. 9702_w19_qp_43 Q: 10

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

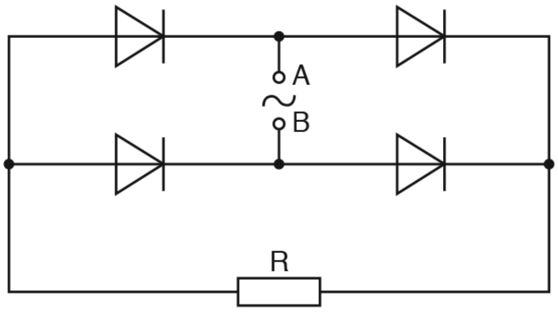

Fig. 10.1

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.

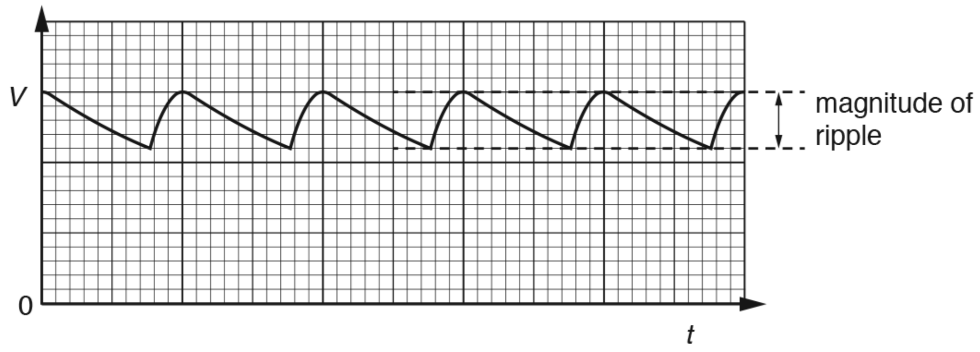

Fig. 10.2

(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]

337. 9702_w17_qp_42 Q: 11

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

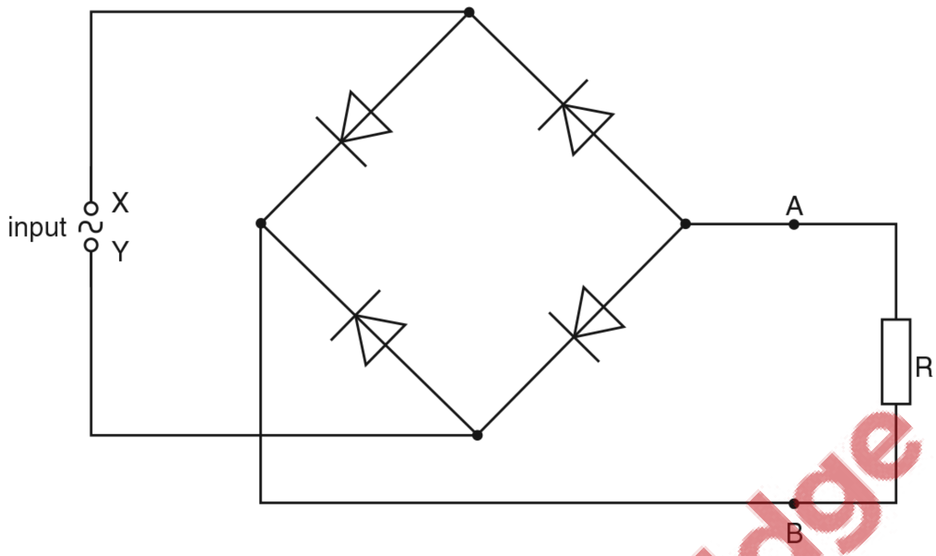

Fig. 11.1

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.

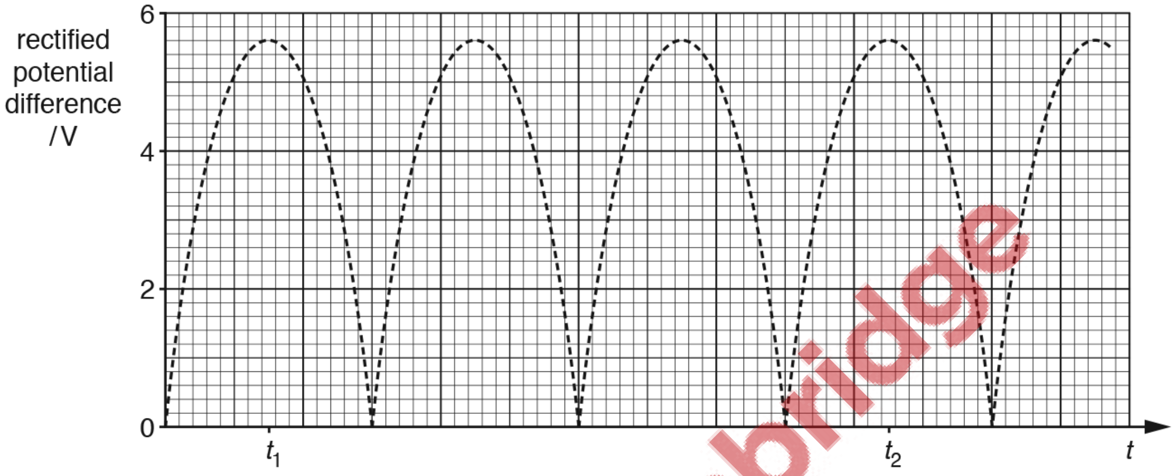

Fig. 11.2

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]

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]