**1.** Nov/2023/Paper_9702/41/No.7

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

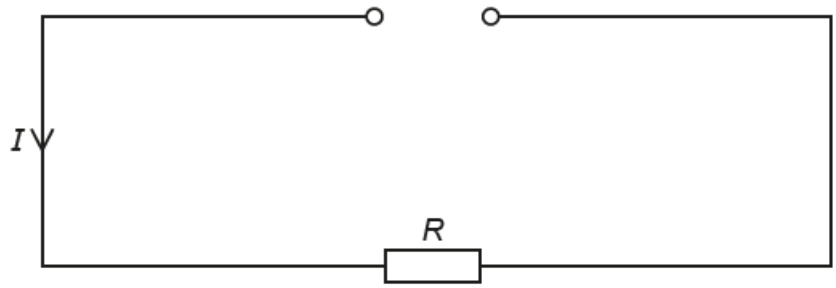


**Fig. 7.1**

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

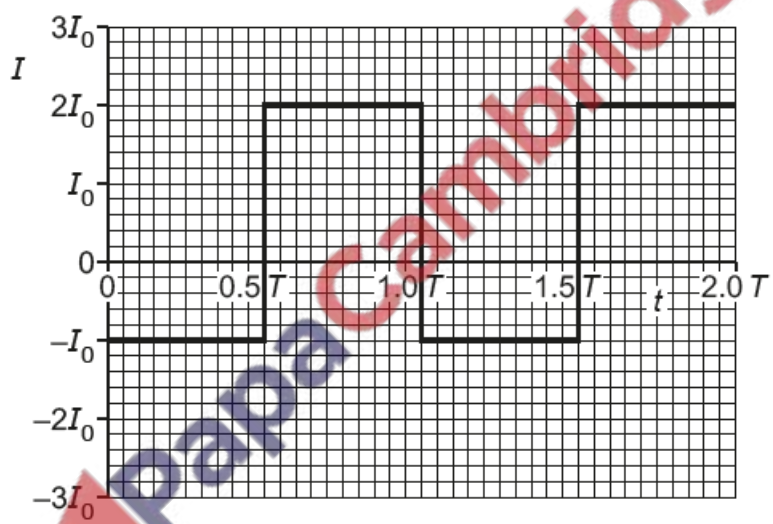


**Fig. 7.2**



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.

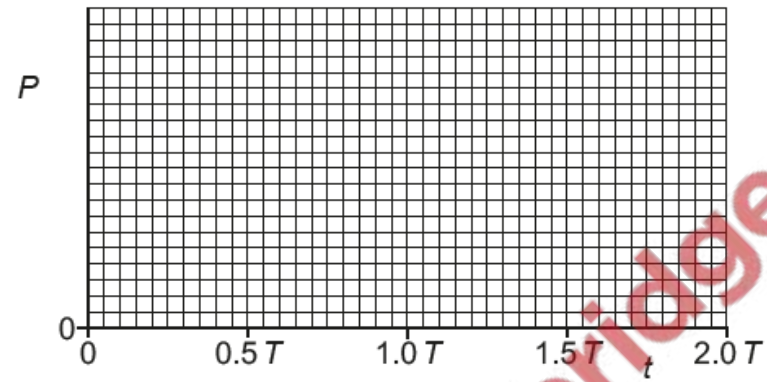


**Fig. 7.3**

[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]

**2.** Nov/2023/Paper_9702/42/No.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.

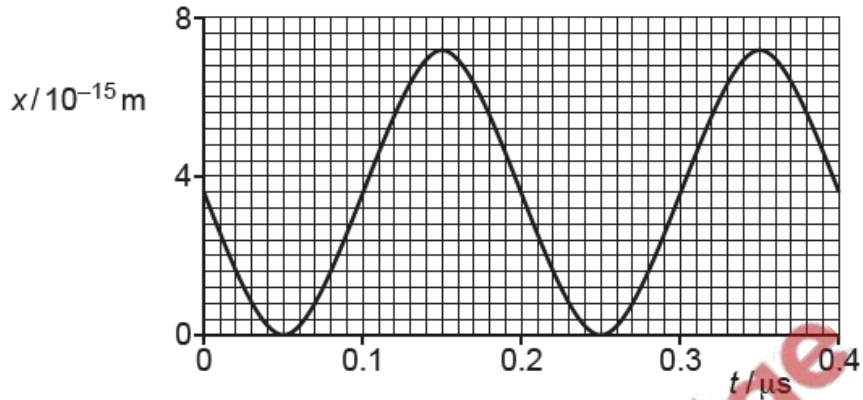


**Fig. 4.1**

**(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 $4.3\,cm^2$ and contains a number density of conduction electrons (charge carriers) of $8.5 \times 10^{28}\,m^{-3}$.

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 $t = 0.40\,\mu s$.

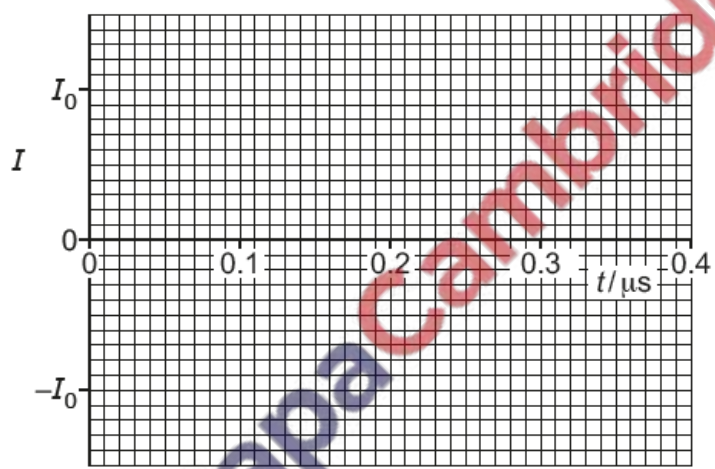


**Fig. 4.2**

[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]

**3.** June/2023/Paper_9702/41/No.5(a, c)

Part of an electric circuit is shown in Fig. 5.1.

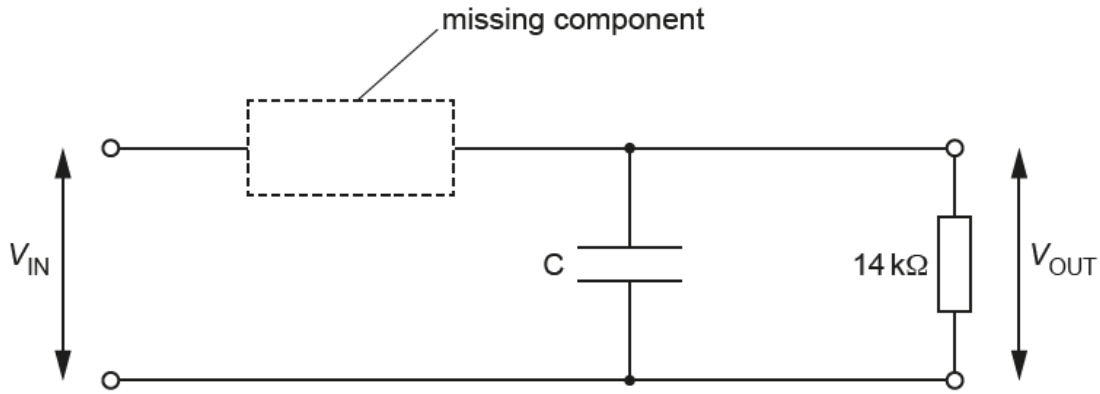


**Fig. 5.1**

The circuit is used to produce half-wave rectification of an alternating voltage of potential difference (p.d.) $V_{IN}$.

The output p.d. across the 14 kΩ resistor is $V_{OUT}$.

**(a) (i)** A component is missing from the circuit of Fig. 5.1.

Complete the circuit diagram in Fig. 5.1 by adding the circuit symbol for the missing component, correctly connected. [1]

**(ii)** A capacitor C is shown in the circuit of Fig. 5.1.

State the effect on $V_{OUT}$ of including the capacitor in the circuit.

..... [1]

**(c)** The circuit of Fig. 5.1 is modified so that it produces full-wave rectification of an input voltage.

Suggest, with a reason, how $V_{OUT}$ now varies with time when $V_{IN}$ is as shown in Fig. 5.2.

.....

.....

..... [2]

**4.** June/2023/Paper_9702/42/No.7

Four diodes are used in a bridge rectifier circuit to produce rectification of a sinusoidal a.c. input voltage $V_{IN}$.
Fig. 7.1 shows part of the circuit, but three of the diodes are missing.

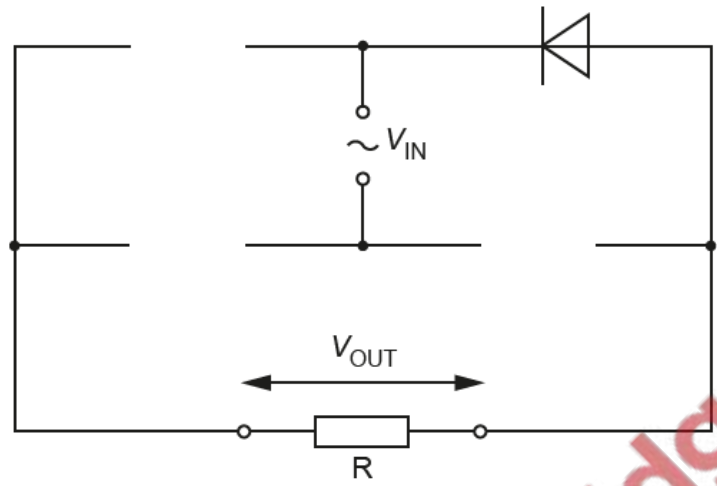


**Fig. 7.1**

The p.d. across the load resistor R is the output p.d. $V_{OUT}$ of the bridge rectifier.

**(a) (i)** State the name of the type of rectification produced by a bridge rectifier.

..... [1]

**(ii)** Complete Fig. 7.1 by drawing the three missing diodes, correctly connected. [2]

**(iii)** On Fig. 7.1, draw an arrow to indicate the direction of the current in resistor R. [1]

**(b)** $V_{IN}$ has amplitude $V_0$ and period $T$. Fig. 7.2 shows the variation with time $t$ of $V_{IN}$.

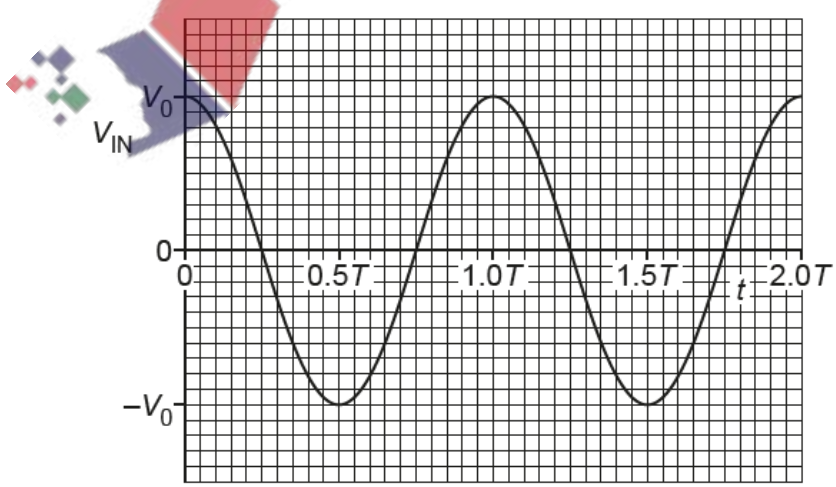


**Fig. 7.2**

**(i)** On Fig. 7.3, sketch the variation of $V_{OUT}$ with $t$ between $t = 0$ and $t = 2.0T$.

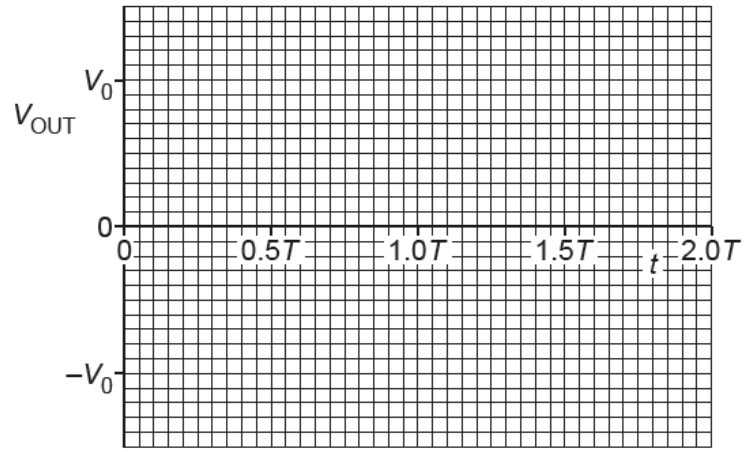


**Fig. 7.3**

[3]

**(ii)** The power dissipated in the resistor is $P$.

On Fig. 7.4, sketch the variation of $P$ with $t$ between $t = 0$ and $t = 2.0T$.


**Fig. 7.4**

[2]

**(iii)** Suggest, with a reason, how the root-mean-square (r.m.s.) value of $V_{OUT}$ compares with the r.m.s. value of $V_{IN}$.

.....

..... [1]

[Total: 10]