21. Alternating Currents

21.1 Characteristics of alternating currents

Paper 4

Marking Scheme

Q1.

(b)(i)	$P = V^2 / R$ **or** maximum $V = 9.0$ V	**C1**
	$P_{MAX} = 9.0^2 / 370 = 0.22$ W	**A1**
(b)(iii)	mean power = peak power / 2 = 0.22 / 2 = 0.11 W	**A1**
(c)	power–time graph is identical	**B1**
	(so) mean powers are equal	**B1**

Q2.

(b)(v)	$A = 0.82$ V **or** A has same numerical value as answer in **(b)(iii)**, with unit V	**A1**
	$B = 2\pi / (2.0 \times 10^{-3})$	**C1**
	$= 3100$ rad s^{-1}	**A1**

Q3.

(a)	number of cycles per unit time	**B1**
(b)(i)	period = $2\pi / 40\pi = 0.050$ s = 50 ms	**A1**
(b)(ii)	sinusoidal curve, starting at (0, 0) and initially increasing from there	**B1**
	periodic line showing 2 cycles with period 50 ms from $t = 0$ to $t = 100$ ms	**B1**
	all peaks shown at $I = +3.5$ A and all troughs shown at $I = -3.5$ A	**B1**
(b)(iii)	$I_{r.m.s} = 3.5 / \sqrt{2}$ $= 2.5$ A	**A1**
(c)	$P = I^2R$	**C1**
	peak power = $3.5^2 \times 680$ (= 8330 W) **or** mean power = $2.47^2 \times 680$ (= 4170 W)	**M1**
	peak and mean powers both calculated correctly, with supporting working, and compared leading to conclusion that mean power is half the peak power	**A1**

Q4.

(b)(i)	frequency = 1 / 0.04 = 25 Hz	**A1**

Q5.

(b)(ii)	sketch: sinusoidal curve with troughs sitting on the time axis	**B1**
	peak power at $t = 0$, $0.5T$, $1.0T$, $1.5T$ and $2.0T$ and zero power half-way in between each peak	**B1**
(b)(iii)	same power-time graph with or without rectification, so same V_{rms} **or** V^2-time graph is same for both V_{OUT} and V_{IN}, so same V_{rms} **or** power does not depend on sign of V, so same V_{rms}	**B1**

Q6.

(a)(i)	$P = I_0^2R$	**A1**
(a)(ii)	$P = 4I_0^2R$	**A1**
(b)	sketch: square wave of period T, with P always non-zero	**B1**
	horizontal lines, from 0 to 0.5T and from 1.0T to 1.5T, all at the same level that the scale indicates to be I_0^2R	**B1**
	horizontal lines, from 0.5T to 1.0T and from 1.5T to 2.0T, at a level that is four times higher than the lower lines	**B1**
(c)(i)	$\langle P \rangle = (5/2)I_0^2R$	**A1**
(c)(ii)	$\langle P \rangle = I_{r.m.s.}^2R$	**C1**
	$I_{r.m.s.}^2R = (5/2)I_0^2R$ $I_{r.m.s.} = \sqrt{(5/2)}\ I_0$	**A1**

Q7.

(b)(i)	$I_0 = nAv_0e$ $= 8.5 \times 10^{28} \times 4.3 \times 10^{-4} \times 1.1 \times 10^{-7} \times 1.60 \times 10^{-19}$	**C1**
	$= 0.64$ A	**A1**
(b)(ii)	sketch: two cycles of sinusoidal curve of amplitude I_0 and period 0.20 μs	**B1**
	correct phase, with $I = +I_0$ at $t = 0$	**B1**
(b)(iii)	equation of form $I = I_0 \cos \omega t$	**M1**
	value of I_0 used matches answer to **(b)(i)** and value of ω used matches answer to **(a)(ii)** [if **(a)(ii)** and **(b)(i)** correct then $I = 0.64 \cos (3.1 \times 10^7\ t)$]	**A1**
(b)(iv)	$I_{r.m.s.} = I_0 / \sqrt{2}$ $= 0.64 / \sqrt{2}$ $= 0.45$ A	**A1**

Q8.

(b)(ii)	V_{OUT} scale labelled 4 and 8 on the 2 cm tick marks	**B1**
	$T = 2\pi / \omega$ $= 2\pi / 25\pi$ $= 0.08$ s	**C1**
	t scale labelled 0.02, 0.04, 0.06, 0.08, 0.10, 0.12 on the 2 cm tick marks	**A1**

Q9.

(a)(i)	peak voltage $= 4.2 \times \sqrt{2}$ $(= 5.9$ V)	**B1**
	power $= V^2 / R$ $= 5.9^2 / 760 = 0.046$ W or 46 mW	**A1**
(a)(ii)	sketch shows peak(s) in power at 46 mW	**B1**
	correct shape (sinusoidal wave sitting on t-axis)	**B1**
	four cycles of repeating pattern shown, with $P = 0$ at 0, 10, 20, 30, 40 μs	**B1**
(a)(iii)	line is symmetrical about 23 mW	**B1**

Q10.

(b)(i)	X = 0.85 A	**A1**
	Y = 2π / 0.040	**C1**
	= 160 rad s^{-1}	**A1**

Q11.

(a)	the steady current **or** the direct current	**M1**
	that produces the same heating effect (as the alternating current)	**A1**
(b)(i)	peak current = 2.6 A **and** r.m.s. current = 1.8 A	**A1**
(b)(ii)	peak current = 2.0 A **and** r.m.s. current = 2.0 A	**A1**
(c)(i)	k = $2\pi f$	**C1**
	= $2\pi \times 50$ = 310 rad s^{-1}	**A1**
(c)(ii)	power = V_{RMS}^2 / R **or** power = $V_0^2 / 2R$	**C1**
	R = $(240 / \sqrt{2})^2 / 3200$ **or** R = $240^2 / (2 \times 3200)$ R = 9.0 Ω	**A1**

Q12.

(a)	constant voltage	**M1**
	that produces/dissipates same power as (the mean power of) the alternating voltage	**A1**
(b)(ii)	sketch: (sinusoidal) wave of period 10 ms	**B1**
	peak E shown as ± 34 V (*1 mark out of 2 awarded if peak E shown as* ± 17 V *or* ± 24 V)	**B2**

Q13.

(b)(ii)	r.m.s. current = $300 / (640 \times \sqrt{2})$ = 0.33 A	**A1**
(b)(iii)	sketch: sinusoidal shape in positive half of the graph, sitting with 'minima' resting on the time-axis (at P = 0)	**B1**
	each 'cycle' shown repeating every 20 ms	**B1**
	maximum P shown as 140 W	**B1**
(c)	power curve is symmetrical about the midpoint (on the power axis)	**B1**
	mean power is half the peak power	**B1**

Q14.

(a)	V_{MAX} = 15 V	**A1**
(b)	210 = $2\pi / T$	**C1**
	T = 0.0299 s	**C1**
	$(t_2 - t_1)$ = 0.060 s	**A1**

Q15.

(a)(ii)	maximum = $7.0\sqrt{2}$ = 9.9 V	**A1**

Q16.

(a)	$V_0 = \sqrt{2} \times V_{r.m.s.} = \sqrt{2} \times 9.9$ (= 14 V) **and** $\omega = 2\pi f = 2\pi \times 50$ (= 314 rad s^{-1})	**C1**
	$V = 14 \sin 314t$	**A1**