inkPhysics

ANSWER BOOK

Alternating currents

Magnetic fields · Year 13

AQA 3.7.5.5 · CIE 21.1.1, 21.1.2, 21.1.3, 21.1.4 · OCR A 4.4.1(b)(ii)

18 questions · 49 marks

NAVY EDITION

SECTION A · Warm-up

A1 The value of the steady direct current (1); that would dissipate the same average power in a given resistor as the alternating current (1). [2]

A2 $V_{rms} = V_{peak}/\sqrt{2} = 10/\sqrt{2}$ (1) [2]
$V_{rms} = 7.07$ V (1)

A3 Peak-to-peak value = 2 × 15 = 30 V (1). [1]

A4 $T = 1/f = 1/50 = 0.020$ s (1) [2]
$\omega = 2\pi f = 2\pi \times 50 = 314$ rad s^{-1} (1)

A5 $T = 4.0 \times 5.0$ ms = 20 ms (1) [2]
$f = 1/T = 1/0.020 = 50$ Hz (1)

SECTION B · Standard

B1 $V_{peak} = \sqrt{2} \times V_{rms} = \sqrt{2} \times 230$ (1) [2]
$V_{peak} = 325.3$ V (1)

B2 $I_{rms} = I_{peak}/\sqrt{2} = 4.0/\sqrt{2}$ (1) [2]
$I_{rms} = 2.83$ A (1)

B3 $I_{rms} = V_{rms}/R = 12/6.0 = 2.0$ A (1) [4]
Mean power = $V_{rms}I_{rms} = 12 \times 2.0 = 24$ W (1)
Peak power = $V_{peak}I_{peak} = 48$ W (1)
Peak power is twice the mean power (1).

B4 $V_{rms} = V_{peak}/\sqrt{2} = 4.0/\sqrt{2}$ (1) [2]
$V_{rms} = 2.83$ V (1)

B5 Peak voltage = 325 V (1) [3]
$\omega = 100\pi$ rad s^{-1}, so $f = \omega/2\pi = 50$ Hz (1)
$V_{rms} = 325/\sqrt{2} = 230$ V (1)

B6 $I_{rms} = 2.6/\sqrt{2} = 1.84$ A (1) [3]
$P = I_{rms}^2 R = 1.84^2 \times 15$ (1)
$P = 51$ W (1)

B7 Peak-to-peak voltage = 6.4 × 0.50 = 3.2 V (1) [3]
V_{peak} = 3.2/2 = 1.6 V (1)
V_{rms} = 1.6/√2 = 1.13 V (1)

SECTION C · Stretch

C1 T = 4.0 × 5.0 ms = 20 ms (1) [4]
f = 1/T = 50 Hz (1)
V_{peak} = 3.0 × 2.0 = 6.0 V (1)
V_{rms} = 6.0/√2 = 4.24 V (1)

C2 Mean power = $V_{rms}^2/R = 230^2/100$ (1) [3]
P = 529 W (1)
The rms value is defined as the DC value giving the same average power in a resistor, so 230 V DC gives the same power (1).

C3 The rms value is the steady (DC) equivalent for power dissipation (1); it represents the effective heating or working value of the supply over a cycle (1); so AC and DC can be compared directly and average power calculated simply as $P = V_{rms}I_{rms}$ (1). [3]

C4 $P = V_{rms}^2/R$: for 2.0 Ω, $P = 12^2/2.0$ = 72 W (1) [4]
For 3.0 Ω, $P = 12^2/3.0$ = 48 W, below 60 W (1)
Current check for the 2.0 Ω element: I_{rms} = 12/2.0 = 6.0 A, within the 7.0 A limit (1)
Only the 2.0 Ω element meets the 60 W requirement, so choose it (1)

C5 dc: $P = V^2/R = 12^2/6.0$ = 24 W (1) [4]
ac: V_{rms} = 12/√2 = 8.5 V (1)
$P = V_{rms}^2/R = 8.5^2/6.0$ = 12 W (1)
The dc supply makes the lamp brighter, with twice the power, because the ac supply spends most of each cycle below its peak (1)

C6 The power dissipated is proportional to v^2, which is positive in both half-cycles (1); the power is a maximum whenever the voltage reaches +peak or -peak, which happens twice per cycle (1); so the heating peaks at 2 × 50 = 100 times per second (1). [3]