Q1.

5	(a)		the (value of the) direct current	M1	
			that dissipates (heat) energy at the same rate (in a resistor)	A1	**[2]**
			allow 'same power' and 'same heating effect'		
	(b)		$\sqrt{2}I_{rms} = I_0$	B1	**[1]**
	(c)	(i)	power $\propto I^2$ or $P = I^2R$ or $P = VI$	C1	
			ratio = 2.0 (allow 1 s.f.)	A1	**[2]**
		(ii)	advantage: e.g. easy to change the voltage	B1	
			disadvantage: e.g. cables require greater insulation		
			.... rectification – with some justification	B1	**[2]**
	(d)	(i)	3.0 A (allow 1 s.f.)	A1	
		(ii)	3.0 A (allow 1 s.f.)	A1	**[2]**
			Total		**[9]**

Q2.

4	(a)		r.m.s. output = 9/√2 or peak input = 230√2	C1	
			$N_S/N_P = V_S/V_P$	C1	
			N_S = 138 → 140 turns	A1	[3]
	(b)	(i)	four diodes correctly positioned regardless of output polarity	M1	
			giving correct output polarity (*all 'point to left'*)	A1	[2]
		(ii)	capacitor shown in parallel with R	B1	[1]
	(c)	(i)	time t_1 to time t_2	B1	[1]
		(ii)	sketch: same peak values	M1	
			ripple reduced and reasonable shape	A1	[2]

Q3.

6	(a)	all four diodes correct to give output, regardless of polarity	M1	
		connected for correct polarity	A1	[2]
	(b)	$N_S / N_P = V_S / V_P$	C1	
		$V_0 = \sqrt{2} \times V_{rms}$	C1	
		ratio = 9.0 / (√2 × 240)		
		= 1/38 or 1/37 or 0.027	A1	[3]

Q4.

7 (a)	*either*	the value of steady / constant voltage	M1	
		that produces same power (in a resistor) as the alternating voltage	A1	[2]
	or	if alternating voltage is squared and averaged	(M1)	
		the r.m.s. value is the square root of this averaged value	(A1)	
(b)	(i)	220 V	A1	[1]
	(ii)	156 V	A1	[1]
	(iii)	60 Hz	A1	[1]
(c)		power = V_{rms}^2 / R	C1	
		$R = 156^2 / 1500$		
		$= 16\,\Omega$	A1	[2]

Q5.

6 (a)	(i)	to concentrate the (magnetic) flux / reduce flux losses	B1	[1]
	(ii)	changing flux (in core) induces current in core	M1	
		currents in core give rise to a heating effect	A1	[2]
(b)	(i)	e.m.f. induced proportional to	M1	
		rate of change of (magnetic) flux (linkage)	A1	[2]
	(ii)	magnetic flux in phase with / proportional to e.m.f. / current in primary coil	M1	
		e.m.f. / p.d. across secondary proportional to rate of change of flux	M1	
		so e.m.f. of supply not in phase with p.d. across secondary	A0	[2]
(c)	(i)	for same power (transmission), high voltage with low current	B1	
		with low current, less energy losses in transmission cables	B1	[2]
	(ii)	voltage is easily / efficiently changed	B1	[1]

Q6.

6 (a)	(i)	$2\pi f = 380$	C1	
		frequency = 60 Hz	A1	[2]
	(ii)	$I_{RMS} \times \sqrt{2} = I_0$	C1	
		$I_{RMS} = 9.9 / \sqrt{2}$		
		$= 7.0\,A$	A1	[2]
(b)		power = I^2R	C1	
		$R = 400 / 7.0^2$		
		$= 8.2\,\Omega$	A1	[2]

Q7.

6	(a)	(i) peak voltage = 4.0 V	A1	[1]
		(ii) r.m.s. voltage (= 4.0/√2) = 2.8 V	A1	[1]
		(iii) period T = 20 ms frequency = 1 / (20 × 10^{-3}) frequency = 50 Hz	M1 M1 A0	[2]
	(b)	(i) change = 4.0 – 2.4 = 1.6 V	A1	[1]
		(ii) $\Delta Q = C\Delta V$ or $Q = CV$ = 5.0 × 10^{-6} × 1.6 = 8.0 × 10^{-6} C	C1 A1	[2]
		(iii) discharge time = 7 ms current = (8.0 × 10^{-6}) / (7.0 × 10^{-3}) = 1.1(4) × 10^{-3} A	C1 M1 A0	[2]
	(c)	average p.d. = 3.2 V resistance = 3.2 / (1.1 × 10^{-3}) = 2900 Ω *(allow 2800 Ω)*	C1 A1	[2]

Q8.

6	(a)	(i) to reduce power loss in the core due to eddy currents/induced currents	B1 B1	[2]
		(ii) *either* no power loss in transformer *or* input power = output power	B1	[1]
	(b)	*either* r.m.s. voltage across load = 9.0 × (8100 / 300) peak voltage across load = √2 × 243 = 340 V	C1 A1	[2]
		or peak voltage across primary coil = 9.0 × √2 peak voltage across load = 12.7 × (8100/300) = 340 V	(C1) (A1)	

Q9.

6 (a)		(induced) e.m.f. <u>proportional to rate</u> of change of (magnetic) flux (linkage)	M1 A1	[2]
(b)	(i)	positive terminal identified (upper connection to load)	B1	[1]
	(ii)	$V_P = \sqrt{2} \times V_{RMS}$ ratio = $240\sqrt{2} / 9$ = 38 ($V_P = V_{RMS} / \sqrt{2}$ *gives ratio* = 18.9 *and scores* 1/3) (*ratio* = 240 / 9 = 26.7 *scores* 1/3) (*ratio* = 9 / (240 / $\sqrt{2}$) = 0.0265 *is inverted ratio and scores* 1/3)	C1 C1 A1	[3]
(c)	(i)	e.g. (output) p.d. / voltage / current does not fall to zero e.g. range of (output) p.d. / voltage / current is reduced *(any sensible answer)*	B1	[1]
	(ii)	sketch: same peak value at start of discharge correct shape between one peak and the next	M1 A1	[2]

Q10.

4 (a)		single diode................................M1 in series with R *OR* in series with a.c. supply................ A1		[2]
(b)	(i)1	5.4 V (allow ± 0.1 V)................................ A1		
	(i)2	$V = iR$ $I = 5.4/1.5 \times 10^3$ .... C1 $= 3.6 \times 10^{-3}$ A A1		
	(i)3	time = 0.027 s A1		[4]
	(ii)1	$Q = it$ $= 3.6 \times 10^{-3} \times 0.027$ .... C1 $= 9.72 \times 10^{-5}$ C A1		
	(ii)2	$C = \Delta Q/\Delta V$ (allow $C - Q/V$ for this mark) .... C1 $= (9.72 \times 10^{-5})/1.2$ $= 8.1 \times 10^{-5}$ F A1		[4]
(c)		line: reasonable shape with less ripple................................ B1		[1]

Q11.

6 (a)	(i)	peak voltage = $6\sqrt{2}$ peak voltage = 8.48 V		C1 A1	[2]
	(ii)	zero because *either* no current in circuit (and $V = IR$) *or* all p.d. across diode		B1	[1]
(b)	waveform:	half-wave rectification peak height at about 4.25 cm half-period spacing of 2.0 cm *(allow ±¼ square for height and half-period)*		B1 B1 B1	[3]
(c)	(i)	*capacitor shown in parallel with resistor*		B1	[1]
	(ii)	*either*	energy = $\frac{1}{2}CV^2$ or = $\frac{1}{2}QV$ <u>and</u> $Q = CV$ = $\frac{1}{2} \times 180 \times 10^{-6} \times (6\sqrt{2})^2$ = 6.48×10^{-3} J	C1 C1 A1	[3]
	(iii)	*either* fraction = 0.43^2 or final energy = 1.2 mJ fraction = 0.18		C1 A1	[2]

Q12.

6 (a)	(i)	*either* prevent loss of magnetic flux *or* improves flux linkage with secondary	B1	[1]
	(ii)	<u>reduces</u> eddy current (losses) <u>reduces</u> losses of energy (in core)	B1 B1	[2]
(b)	(i)	(induced) e.m.f. proportional to / equal to rate of change of (magnetic) flux (linkage)	M1 A1	[2]
	(ii)	changing current in primary gives rise to (1) changing flux in core (1) flux links with the secondary coil (1) changing flux in secondary coil, inducing e.m.f. (1)		

	(any three, 1 each to max 3)	B3	[3]
(c)	e.g. can change voltage easily / efficiently high voltage transmission reduces power losses *(any two sensible suggestions, 1 each)*	B2	[2]

Q13.

7	(a)		e.g. more (output) power available e.g. less ripple for same smoothing capacitor *any sensible suggestion*	B1	[1]
	(b)	(i)	curve showing half-wave rectification	B1	[1]
		(ii)	similar to (i) but phase shift of 180°	B1	[1]
	(c)	(i)	correct symbol, connected in parallel with R	B1	[1]
		(ii)	**1** larger capacitor / second capacitor in parallel with R (not increase *R*)	B1	[1]
			2 same peak values correct shape giving less ripple	B1 B1	[2]
					[Total: 7]

Q14.

6	(a)	(i)	e.g. prevent flux losses / improve flux linkage	B1	[1]
		(ii)	flux in core is changing e.m.f. / current (induced) <u>in core</u> induced current in core causes heating	B1 B1 B1	[3]
	(b)	(i)	that value of the direct current producing same (mean) power / heating in a resistor	M1 A1	[2]
		(ii)	power in primary = power in secondary $V_P I_P = V_S I_S$	M1 A1	[2]

Q15.

6	(a)	power / heating depends on I^2 so independent of current direction	M1 A1	[2]
	(b)	*either* maximum power = $I_0{}^2R$ *or* average power = $I_{RMS}{}^2R$ $I_0 = \sqrt{2} \times I_{RMS}$ maximum power = 2 × average power ratio = 0.5	M1 M1 A1	[3]

Q16.

6	**(a)**	**(i)**	period = 1/50	C1
			t_1 = 0.03 s	A1 [2]
		(ii)	peak voltage = 17.0 V	A1 [1]
		(iii)	r.m.s. voltage = 17.0/√2	
			= 12.0 V	A1 [1]
		(iv)	mean voltage = 0	A1 [1]
	(b)		power = V^2/R	C1
			= $12^2/2.4$	
			= 60 W	A1 [2]

Q17.

5	**(a)**		supply connected correctly (to left & right)	B1
			load connected correctly (to top & bottom)	B1 [2]
	(b)		e.g. power supplied on every half-cycle	
			greater <u>average/mean</u> power	
			(any sensible suggestion, 1 mark)	B1 [1]
	(c)	**(i)**	reduction in the variation of the output voltage/current	B1 [1]
		(ii)	larger capacitance produces more smoothing	M1
			either product *RC* larger	
			or for the same load	A1 [2]

Q18.

6	**(a)**	**(i)**	connection to 'top' of resistor labelled as positive	B1 [1]
		(ii)	diode B and diode D	B1 [1]
	(b)	**(i)**	V_P = 4.0 V	C1
			mean power = $V_P^2/2R$	C1
			= 4^2 / (2 × 2700)	
			= 2.96 × 10^{-3} W	A1 [3]
		(ii)	capacitor, correct symbol, connected in parallel with R	B1 [1]
	(c)		graph: half-wave rectification	M1
			same period and same peak value	A1 [2]

Q19.

7	(a)	(i)	*either* heating effect in a resistor $\propto$ (current)^2	B1	
			square of value of an alternating current is always positive	B1	
			so heating effect	A0	
			or current moves in opposite directions in resistor during half-cycles	(B1)	
			heating effect is independent of direction	(B1)	[2]
		(ii)	that value of the direct current	M1	
			producing the same heating effect (as the alternating current) in a resistor	A1	[2]
	(b)	(i)	induced e.m.f. proportional to the rate	M1	
			of change of (magnetic) flux (linkage)	A1	[2]
		(ii)	flux in core is in phase with current in the primary coil	B1	
			(induced) e.m.f. in secondary because coil cuts the flux	B1	
			flux and rate of change of flux are not in phase	B1	[3]