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/$\sqrt{2}$ or peak input = 230$\sqrt{2}$	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 $= 9.0 / (\sqrt{2} \times 240)$		
		$= 1/38$ 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_{ms}^2 / R		C1	
		R = 156^2 / 1500			
		= 16 Ω		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 = $I^2 R$		C1	
		R = 400 / 7.0^2			
		= 8.2 Ω		A1	[2]

Q7.

MEGA LECTURE

6	(a)	(i)	peak voltage = 4.0 V	A1	[1]
		(ii)	r.m.s. voltage $(= 4.0/\sqrt{2}) = 2.8$ V	A1	[1]

		(iii)	period $T = 20$ ms	M1	
			frequency $= 1 / (20 \times 10^{-3})$	M1	
			frequency $= 50$ Hz	A0	[2]

	(b)	(i)	change $= 4.0 - 2.4 = 1.6$ V	A1	[1]
		(ii)	$\Delta Q = C\Delta V$ or $Q = CV$	C1	
			$= 5.0 \times 10^{-6} \times 1.6 = 8.0 \times 10^{-6}$ C	A1	[2]

		(iii)	discharge time $= 7$ ms	C1	
			current $= (8.0 \times 10^{-6}) / (7.0 \times 10^{-3})$	M1	
			$= 1.1(4) \times 10^{-3}$ A	A0	[2]

	(c)		average p.d. $= 3.2$ V	C1	
			resistance $= 3.2 / (1.1 \times 10^{-3})$		
			$= 2900\,\Omega$ *(allow 2800Ω)*	A1	[2]

Q8.

6	(a)	(i)	to reduce power loss in the core	B1	
			due to eddy currents/induced currents	B1	[2]
		(ii)	*either* no power loss in transformer		
			or input power = output power	B1	[1]

	(b)	*either*	r.m.s. voltage across load $= 9.0 \times (8100 / 300)$	C1	
			peak voltage across load $= \sqrt{2} \times 243$		
			$= 340$ V	A1	[2]
		or	peak voltage across primary coil $= 9.0 \times \sqrt{2}$	(C1)	
			peak voltage across load $= 12.7 \times (8100/300)$		
			$= 340$ V	(A1)	

Q9.

6 (a) (induced) e.m.f. <u>proportional to rate</u>   M1
           of change of (magnetic) flux (linkage)   A1 [2]

    (b) (i) positive terminal identified (upper connection to load)   B1 [1]

         (ii) $V_P = \sqrt{2} \times V_{RMS}$ C1
              ratio = 240 $\sqrt{2}$ / 9   C1
                  = 38   A1 [3]
             ($V_P = V_{RMS} / \sqrt{2}$ *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*)

    (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   M1
                   correct shape between one peak and the next   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 = $6\sqrt{2}$	C1	
			peak voltage = 8.48 V	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	B1	
			peak height at about 4.25 cm	B1	
			half-period spacing of 2.0 cm	B1	[3]
			(allow ±¼ square for height and half-period)		
	(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> $Q = CV$	C1	
			= $\frac{1}{2} \times 180 \times 10^{-6} \times (6\sqrt{2})^2$	C1	
			= 6.48×10^{-3} J	A1	[3]
		(iii)	*either* fraction = 0.43^2 or final energy = 1.2 mJ	C1	
			fraction = 0.18	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)	B1	
			<u>reduces</u> losses of energy (in core)	B1	[2]
	(b)	(i)	(induced) e.m.f. proportional to / equal to	M1	
			rate of change of (magnetic) flux (linkage)	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)		

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	(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 .... B1 [1]
           (not increase *R*)
           2 same peak values B1
           correct shape giving less ripple .... B1 [2]

                                                                                    [Total: 7]

Q14.

6 (a) (i) e.g. prevent flux losses / improve flux linkage   B1   [1]

       (ii) flux in core is changing   B1
           e.m.f. / current (induced) <u>in core</u>   B1
           induced current in core causes heating   B1   [3]

   (b) (i) that value of the direct current producing same (mean) power / heating   M1
           in a resistor   A1   [2]

       (ii) power in primary = power in secondary   M1
           $V_P I_P = V_S I_S$ A1   [2]

Q15.

6 (a) power / heating depends on I^2 M1
       so independent of current direction   A1   [2]

   (b) *either* maximum power = $I_0^2 R$ *or* average power = $I_{RMS}^2 R$ M1
       $I_0 = \sqrt{2} \times I_{RMS}$ M1
       maximum power = 2 × average power
       ratio = 0.5   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   = $17.0/\sqrt{2}$
                       = 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 average/mean 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
        = $4^2 / (2 \times 2700)$
        = 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]