Q1.

5 (a) the (value of the) direct current that dissipates (heat) energy at the same rate (in a resistor) allow 'same power' and 'same heating effect' M1 A1 [2]

(b) \( \sqrt{2}_r / I_{\text{rms}} = I_0 \) B1 [1]

(c) (i) power \( P = I^2 R \) or \( P = IV \) C1 A1 [2]

(ii) ratio = 2.0 (allow 1 s.f.) B1 [2]

(iii) advantage: e.g. easy to change the voltage disadvantage: e.g. cables require greater insulation

........ rectification -- with some justification

(d) (i) 3.0 A (allow 1 s.f.) A1 [2]

(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}

\( N_b / N_a = V_b / V_a \) C1

\( N_b = 138 \rightarrow 140 \) turns A1 [3]

(b) (i) four diodes correctly positioned regardless of output polarity giving correct output polarity (in 'point to left') M1 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 ripple reduced and reasonable shape M1 A1 [2]

Q3.

6 (a) all four diodes correct to give output, regardless of polarity connected for correct polarity M1 A1 [2]

(b) \( N_b / N_a = V_b / V_a \) C1

\( V_b = \sqrt{2} \times V_{\text{rms}} \) C1

ratio = \( 9.0 / (\sqrt{2} \times 240) \) A1 [3]

= \( 1/38 \) or \( 1/37 \) or 0.027

Q4.
7 (a) either the value of steady / constant voltage that produces same power (in a resistor) as the alternating voltage or if alternating voltage is squared and averaged the r.m.s. value is the square root of this averaged value

(b) (i) 220 V
(ii) 156 V
(iii) 60 Hz

(c) power = \( V_{rms}^2 / R \)
\[ R = 156^2 / 1500 \]
\[ = 16 \, \Omega \]

Q5.

6 (a) (i) to concentrate the (magnetic) flux / reduce flux losses
(ii) changing flux (in core) induces current in core currents in core give rise to a heating effect

(b) (i) e.m.f. induced proportional to rate of change of (magnetic) flux (linkage)
(ii) magnetic flux in phase with / proportional to e.m.f. / current in primary coil e.m.f. / p.d. across secondary proportional to rate of change of flux so e.m.f. of supply not in phase with p.d. across secondary

(c) (i) for same power (transmission), high voltage with low current with low current, less energy losses in transmission cables
(ii) voltage is easily / efficiently changed

Q6.

6 (a) (i) \( 2 \pi f = 360 \)
\[ f = 60 \, Hz \]
(ii) \( I_{RMS} \times \sqrt{2} = I_0 \)
\[ I_{RMS} = 9.9 / \sqrt{2} \]
\[ = 7.0 \, A \]

(b) power = \( I^2 R \)
\[ R = 400 / 7.0^2 \]
\[ = 8.2 \, \Omega \]

Q7.
Q8.

6 (a) (i) peak voltage = 4.0 V
   (ii) r.m.s. voltage (= 4.0/\sqrt{2}) = 2.8 V
   (iii) period T = 20 ms
        frequency = 1 / (20 \times 10^{-3})
        frequency = 50 Hz

(b) (i) change = 4.0 - 2.4 = 1.6 V
   (ii) \Delta Q = C \Delta V \text{ or } Q = CV
        = 5.0 \times 10^{-6} \times 1.6 = 8.0 \times 10^{-6} \text{C}
   (iii) discharge time = 7 ms
        current = \frac{(8.0 \times 10^{-6})}{(7.0 \times 10^{-3})}
        = 1.1(4) \times 10^{-3} \text{A}

(c) average p.d. = 3.2 V
    resistance = \frac{3.2}{(1.1 \times 10^{-3})}
    = 2900 \Omega \text{ (allow 2800\Omega)}

Q8.

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

(b) either r.m.s. voltage across load = 9.0 \times \frac{8100}{300}
    peak voltage across load = 12 \times 243
    = 340 V
    or peak voltage across primary coil = 9.0 \times \sqrt{2}
    peak voltage across load = 12.7 \times \frac{8100}{300}
    = 340 V

Q9.
6 (a) (induced) e.m.f. proportional to rate of change of (magnetic) flux (linkage) \[ M1 \]
A1 [2]

(b) (i) positive terminal identified (upper connection to load) \[ B1 \]
A1 [1]

(ii) \[ V_p = \sqrt{2} \times V_{RMS} \]
\[ \text{ratio} = 240/\sqrt{2} = 38 \]
\[ V_p = V_{RMS} / \sqrt{2} \text{ gives ratio} = 18.9 \text{ and scores } 1/3 \]
\[ \text{ratio} = 240/9 = 26.7 \text{ scores } 1/3 \]
\[ \text{ratio} = 9 / (240 / \sqrt{2}) = 0.0265 \text{ is inverted ratio and scores } 1/3 \]

(c) (i) e.g. (output) p.d. / voltage / current does not fall to zero
\[ e.g. \text{ range of (output) p.d. / voltage / current is reduced (any sensible answer)} \]
\[ B1 \]
A1 [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 in series with R OR in series with a.c. supply \[ M1 \]
A1 [2]

(b) (i) \[ 5.4 \text{ V (allow } \pm 0.1 \text{ V)} \]
\[ A1 \]

(ii) \[ V = IR \]
\[ I = 5.4/1.5 \times 10^{-3} \]
\[ = 3.6 \times 10^{-3} \text{ A} \]
\[ C1 \]
A1

(iii) \[ \text{time} = 0.027 \text{ s} \]
\[ A1 \]
[4]

(ii) \[ Q = \int \]
\[ = 3.6 \times 10^{-3} \times 0.027 \]
\[ = 9.72 \times 10^{-5} \text{ C} \]
\[ C1 \]
A1

(ii) \[ C = \Delta Q / \Delta V \text{ (allow } C - Q/V \text{ for this mark)} \]
\[ = (9.72 \times 10^{-5})/1.2 \]
\[ = 8.1 \times 10^{-5} \text{ F} \]
\[ C1 \]

(c) line: reasonable shape with less ripple \[ B1 \]
[1]

Q11.
Q12.

6 (a) (i) peak voltage = $6 \sqrt{2}$
peak voltage = 8.48 V

(ii) zero because either no current in circuit (and $V = IR$)
or all p.d. across diode

(b) waveform: half-wave rectification
peak height at about 4.25 cm
half-period spacing of 2.0 cm
(also 1/4 square for height and half-period)

(c) (i) capacitor shown in parallel with resistor

(ii) either $\text{energy} = \frac{1}{2} CV^2$ or $\text{energy} = \frac{1}{2} QV$ and $Q = CV$
= $\frac{1}{2} \times 180 \times 10^{-8} \times (6\sqrt{2})^2$
= $6.48 \times 10^{-3}$ J

(iii) either fraction = 0.43$^2$ or final energy = 1.2 mJ
fraction = 0.18

Q13.
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) in core  
  induced current in core causes heating  
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  
\[ V_1 I_1 = V_2 I_2 \]  
M1  
A1 [2]

Q15.

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

(b) either  
maximum power = \( I_0^2 R \)  
or  
average power = \( I_{\text{rms}}^2 R \)  
\[ I_0 = \sqrt{2} \times I_{\text{rms}} \]  
M1  
M1

maximum power = 2 \times \text{average power}  
ratio = 0.5  
M1  
A1 [3]

Q16.
Q17.

5 (a) supply connected correctly (to left & right)
load connected correctly (to top & bottom)

(b) e.g. power supplied on every half-cycle
greater average/mean power
(any sensible suggestion, 1 mark)

Q18.

6 (a) (i) connection to 'top' of resistor labelled as positive
(ii) diode D and diode D

(b) (i) $V_r = 4.0 \text{ V}$
mean power $= \frac{V_r^2}{2R}$
$= \frac{4^2}{2 \times 2700}$
$= 2.96 \times 10^{-3} \text{ W}$

(ii) capacitor, correct symbol, connected in parallel with R

(c) graph: half-wave rectification
same period and same peak value

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  \[ B1 \]  \[3\]