1)

(a)		(use of $1/R_{total} = 1/R_1 + 1/R_2$) $1/R_{total}$ = 1/400 + 1/400 = 2/400 R_{total} = 200 Ω ✓ (working does not need to be shown) hence total resistance = 25 + 200 = 225 Ω ✓	**2**
(b)	(i)	(use of $P = V^2/R$) $1 = V^2/400$ ✓ $V^2 = 400$ (working does not need to be shown) V = 20 V ✓	**6**
	(ii)	(use of $I = V/R$) I = 20/400 = 0.05 A ✓ (working does not need to be shown) hence current = 2 × 0.05 = 0.10 A ✓	
	(iii)	(use of $V = IR$) pd across 25 Ω resistor = 25 × 0.10 = 2.5 V ✓ (working does not need to be shown) hence maximum applied pd = 20 + 2.5 = 22.5 V ✓	
		Total	**8**

2)

(a)	(i)	6.0 (Ω) ✓	**1**
(a)	(ii)	4.5 (V) ✓	**1**
(a)	(iii)	(use of $I = V/R$) I = 4.5/6.0 = 0.75 (A) ✓ current through cell A = 0.75/2 = 0.375 (A) ✓	**2**
(a)	(iv)	charge = 0.375 × 300 = 112 ✓ C ✓	**2**
(b)		cells C and D will go flat first or A and B last longer ✓ current/charge passing through cells C and D (per second) is double/more than that passing through A or B ✓ energy given to charge passing through cells **per second** is double or more than in cells C and D ✓ or in terms of power	**3**
		Total	**9**

3)

a		(use of $P = VI$) I = 36/12 = 3.0 A ✓ I = 2.0/4.5 = 0.44 A ✓	**2**
b	i	pd = 24 – 12 = 12 V ✓	**1**
b	ii	current = 3.0 + 0.44 = 3.44 A ✓	**1**
b	iii	R_1 = 12/3.44 = 3.5 Ω ✓	**1**
b	iv	pd = 12 – 4.5 = 7.5 V ✓	**1**
b	v	R_2 = 7.5/0.44 = 17 Ω ✓	**1**
c	i	(circuit) resistance increases ✓ current is lower (reducing voltmeter reading) ✓ **or** correct potential divider argument	**2**
c	ii	pd across Y **or** current through Y increases ✓ hence power/rate of energy dissipation greater **or** temperature of lamp increases ✓	**2**
		Total	**11**

4)

a	i	(use of $R = V/I$) R = 10/2.0 = 5.0 Ω ✓	**1**
a	ii	$\frac{1}{R} = \frac{1}{3} + \frac{1}{3+3} = \frac{3}{6}$ ✓ R = 2 (Ω) ✓ R_{total} = 2 + 3 ✓ (= 5 Ω)	**3**
b	i	voltage across Y = 10.0 – 2.0 × 3.0 = 4.0 V ✓ current in Y = 4.0/3.0 = 1.3 A ✓	**2**
b	ii	current through W = 0.67 A ✓ voltage = 0.67 × 3 = 2.0 V ✓ (**or** 4.0/2 ✓ = 2.0 V ✓)	**2**
		Total	**8**

5)

a	i	*(use of P=VI)* I = 36/12 + 6/12 ✓ = 3.5 (A) ✓	2
a	ii	*(use of V=IR)* R = 12/3 =4 (Ω) ✓	1
a	iii	*R* = 12/0.50 = 24 ✓ (Ω)	1
b		terminal pd/voltage across lamp is now less OR current is less ✓ due to lost volts across internal resistance OR due to higher resistance✓ lamps less bright ✓	3
c	i	current through lamps is reduced as resistance is increased **or** pd across lamps is reduced as voltage is shared ✓ hence power is less OR lamps dimmer ✓	2
c	ii	lamp Q is brighter ✓ lamp Q has the <u>higher resistance</u> hence <u>pd</u>/<u>voltage</u> across is greater ✓ current is the same for both ✓ hence power of Q greater ✓	max 3

6)

a	i	*(use of V = IR)* *I* = (12-8) /60✓ = 0.067 Or 0.066(A) ✓	2
a	ii	*(use of V = IR)* R = 8/0.067 = 120 (Ω) ✓	1
a	iii	*(use of Q = It)* *Q = 0.067 × 120* = 8.0 ✓ C ✓	2
b		reading will increase ✓ resistance (of thermistor) decreases (as temperature increases) ✓ current in circuit increase (so pd across R_1 increases) OR correct potential divider argument ✓	3

7)

(i)	(*use of V=Ir*) V= 4.2 × 1.5✓ = 6.3 (V)	1	
(ii)	pd = 12 – 6.3 = 5.7 V✓	1	NO CE from (i)
(iii)	(*use of I = V/R*) *I* = 5.7/2.0 = 2.8(5) A✓	1	CE from (ii) (a(ii)/2.0) accept 2.8 or 2.9
(iv)	*I* = 4.2 – 2.85 = 1.3(5) A ✓	1	CE from (iii) (4.2 –(a)(iii)) accept 1.3 or 1.4
(v)	*R*= 5.7/1.35 =4.2 Ω ✓	1	CE from (iv) (a(ii)/(a)(iv)) Accept range 4.4 to 4.1
(vi)	$\frac{1}{R_{parallel}} = \frac{1}{4.2} + \frac{1}{2.0} = 0.737$ ✓ $R_{parallel} = 1.35\,\Omega$ R_{total} = 1.35 <u>+ 1.5</u>✓ = 2.85 Ω OR R = 12/4.2✓ R= 2.85 Ω✓	2	CE from (a)(v) second mark for adding internal resistance

(b)	(i)	<table><tr><td>resistor</td><td>Rate of energy dissipation (W)</td></tr><tr><td>1.5 Ω internal resistance</td><td>4.2^2 × 1.5 = 26.5 ✓</td></tr><tr><td>2.0 Ω</td><td>2.85^2 × 2.0 = 16.2 (15.68 – 16.82)✓</td></tr><tr><td>R</td><td>1.35^2 × 4.2 = 7.7 (7.1 – 8.2)✓</td></tr></table>	3	CE from answers in (a) but not for first value 2.0: $a(iii)^2$×2 R: $a(iv)^2$×a(v)
(b)	(ii)	energy provided by cell per second = 12 × 4.2 = <u>50.4</u> (W)✓ energy dissipated in resistors per second = 26.5 + 16.2 + 7.7 = 50.4✓ (hence energy input per second equals energy output)	2	if not equal can score second mark if an appropriate comment

8)

(a)	(i)	(*use of I = V/R*) I = 6.0/(50 000+35 000+5000) ✓= 6.7 × 10^{-5} A✓	2	first mark for adding resistance values 90 k Ω accept 7 × 10^{-5} or dotted 6 × 10^{-5} but not 7.0 × 10^{-5} and not 6.6 × 10^{-5}
(a)	(ii)	V=6.7 × 10^{-5} × 5000 ✓= 0.33 (0.33 – 0.35) V✓ OR V=5/90×6✓ = 0.33(V) ✓	2	CE from (i) BALD answer full credit 0.3 OK and dotted 0.3
(b)		resistance of LDR decreases✓ reading increase because greater <u>proportion/share</u> of the voltage across R OR higher current✓	2	need first mark before can qualify for second
(c)		I= 0.75/5000 = 1.5 × 10^{-4} (A) ✓ (pd across LDR = 0.75 (V)) pd across variable resistor = 6.0 – 0.75 – 0.75 = 4.5 (V) ✓ *R*=4.5/1.5 × 10^{-4} = 30 000 Ω ✓ OR I= 0.75/5000 = 1.5 × 10^{-4} (A) ✓ R_{total} = 6.0/1.5 × 10^{-4} = 40 000 Ω ✓ *R* = 40 000 – 5000 – 5000 = 30 000 Ω ✓	3	

9)

(a)	(i)	voltage = 0.01 × 540 = 5.4 V ✓	**1**
(a)	(ii)	voltage = 15 – 5.4 = 9.6 V ✓	**1**
(a)	(iii)	(use of resistance = voltage/current) resistance = 9.6/0.01 ✓ = 960 Ω ✓ **or** R_T = 15/0.01 = 1500 Ω ✓ R = 150 – 590 = 960 Ω ✓ **or** potential divider ratio ✓✓	**2**
(a)	(iv)	(use of $1/R = 1/R_1 + 1/R_2$) $1/960 = 1/200 + 1/R_2$ ✓ $1/R_2 = 1/960 – 1/1200$ R_2 = 4800 Ω ✓	**2**
(b)		(voltage of supply constant) (circuit resistance decreases) (supply) current increases or potential divider argument ✓ hence pd across 540 Ω resistor increases ✓ hence pd across 1200 Ω decreases ✓ **or** resistance in parallel combination decreases ✓ pd across parallel resistors decreases ✓ pd across 1200 Ω decreases ✓	**3**
		Total	**9**

10)

<table>
<tr><td>a</td><td>(i)</td><td>1/R_{total} = 1/(40) ✓+1/(10+5) ✓= 0.09167
R_{total} = 10.9 kΩ✓</td><td>3</td><td></td></tr>
<tr><td>a</td><td>(ii)</td><td>I = 12/10.9k = 1.1 mA✓</td><td>1</td><td></td></tr>
<tr><td>b</td><td></td><td><table><tr><td>position</td><td>pd/V</td></tr><tr><td>AC</td><td>6.0✓</td></tr><tr><td>DF</td><td>4.0✓</td></tr><tr><td>CD</td><td>2.0✓</td></tr></table></td><td>3</td><td>C.E. for CD</td></tr>
<tr><td>c</td><td>(i)</td><td>AC: no change✓
constant pd across resistors/parallel branches(AE)✓</td><td>2</td><td>no CE from first mark</td></tr>
<tr><td>c</td><td>(ii)</td><td>DF: decreases✓
as greater proportion of voltage across fixed/10 kΩ resistor✓</td><td>2</td><td>no CE from first mark</td></tr>
</table>

11)

a	(i)	(use of $I = V/R$) I = 12/8 ✓= 1.5 A ✓	**5**
	(ii)	I = (12-0.65 ✓)/4 = 2.8 A ✓ sig figs ✓	
(b)	(i)	pd = 6.0 – 1.6 = 4.4 (V) ✓	**1**
(b)	(ii)	current = 4.4/1200 = 3.7×10^{-3} (A) ✓ (not 3.6)	**1**
(b)	(iii)	resistance = 1.6/3.7×10^{-3} = 440 **or** 430 (Ω) ✓ 2 sfs ✓	**2**
(c)		less current now flows **or terminal pd/voltage** lower ✓ (or voltage across cell/external circuit is lower) (hence) pd/voltage across resistor will decrease ✓	**2**
		Total	**11**

12)

(a)	(i)	voltage = 0.01 × 540 = 5.4 V ✓	1
(a)	(ii)	voltage = 15 – 5.4 = 9.6 V ✓	1
(a)	(iii)	(use of resistance = voltage/current) resistance = 9.6/0.01 ✓ = 960 Ω ✓ **or** R_T = 15/0.01 = 1500 Ω ✓ R = 150 – 590 = 960 Ω ✓ **or** potential divider ratio ✓✓	2
(a)	(iv)	(use of $1/R = 1/R_1 + 1/R_2$) $1/960 = 1/200 + 1/R_2$ ✓ $1/R_2 = 1/960 – 1/1200$ R_2 = 4800 Ω ✓	2
(b)		(voltage of supply constant) (circuit resistance decreases) (supply) current increases or potential divider argument ✓ hence pd across 540 Ω resistor increases ✓ hence pd across 1200 Ω decreases ✓ **or** resistance in parallel combination decreases ✓ pd across parallel resistors decreases ✓ pd across 1200 Ω decreases ✓	3
		Total	**9**