10. D.C. Circuits

10.2 Kirchhoff's laws

Paper 2

Marking Scheme

Q1.

(a)	sum of current(s) entering a junction = sum of current(s) leaving (the same junction) **or** (algebraic) sum of current (s) at a junction is zero	**B1**
(b)	(by Kirchhoff's second law) $V = V_1 + V_2$	**B1**
	so $IR_T = IR_1 + IR_2$ (and cancelling I gives) $R_T = R_1 + R_2$ **or** $V / I = V_1 / I + V_2 / I$ (and substituting R gives) $R_T = R_1 + R_2$	**B1**
(d)(i)	the (total) resistance (of the circuit) has decreased (and e.m.f. is unchanged)	**M1**
	(the current (in the cell) will) increase	**A1**

Q2.

(a)	sum of electromotive force(s) = sum of potential difference(s) around a (closed) loop.	**B1**

Q3.

(a)(iii)	$R = 2.7 - 1.0$ $= 1.7\ \Omega$	**A1**

Q4.

(b)(iii)	$I = (230 - 6.0) / 170$ $(= 1.3\ A)$	**C1**
	$I_1 = 7.0 - 1.3$ $= 5.7\ A$	**A1**
(b)(iv)	$V = 230 - 6.0 - (5.7 \times 2.4)$	**C1**
	$= 210\ V$	**A1**
	or	
	$R = ((230 - 6.0) / 5.7) - 2.4$ $(= 36.9\ \Omega)$	**(C1)**
	$V = 5.7 \times 36.9$ $= 210\ V$	**(A1)**
(b)(vii)	(current) decreases	**A1**

Q5.

(b)	$9.6 = 6.2 \times 10^{-4} \times (3400 + 5800 + R)$ **or** $6.0 = 6.2 \times 10^{-4} \times (3400 + R)$	**C1**
	$R = 6.3 \times 10^3\ \Omega$	**A1**
(d)(ii)	decrease	**B1**

Q6.

(a)(ii)	$R = (25 - 16) / 0.050$ **or** $R = (9 / 16) \times 320$ **or** $R = (25 / 0.050) - 320$	**C1**
	$R = 180\ (\Omega)$	**C1**
	$R_{(LDR)} = [(1 / 180) - (1 / 240)]^{-1}$ $= 720\ \Omega$	**A1**
	or	
	$I = (25 - 16) / 240$ $(= 0.0375\ A)$	**(C1)**
	$I_{(LDR)} = 0.050 - 0.0375$ $(= 0.0125\ A)$	**(C1)**
	$R_{(LDR)} = 9.0 / 0.0125$ $= 720\ \Omega$	**(A1)**

Q7.

(b)(iii)	$6.4 / E = 1600 / (1400 + 1600)$ **or** $E = 6.4 + (4.0 \times 10^{-3} \times 1400)$ **or** $E = 4.0 \times 10^{-3}\ (1600 + 1400)$	**C1**
	$E = 12\ V$	**A1**
(c)(ii)	increase	**B1**

Q8.

(a)	sum of current(s) into junction = sum of current(s) out of junction **or** (algebraic) sum of current(s) at a junction is zero	**B1**

Q9.

(a)	$V = V_1 + V_2 + V_3$	**B1**
	$IR = IR_1 + IR_2 + IR_3$ **or** $(V / I) = (V_1 / I) + (V_2 / I) + (V_3 / I)$ **and** $R = R_1 + R_2 + R_3$	**B1**
(b)(ii)	total resistance in parallel $= 3.0 \times 10^3\ (\Omega)$ **or** $3.0\ (k\Omega)$	**C1**
	current $= 8.0 / (3.0 \times 10^3 + 6.0 \times 10^3)$ $= 8.9 \times 10^{-4}\ A$	**A1**

Q10.

(a)	<u>sum of</u> e.m.f.(s) = <u>sum of</u> p.d.(s) **or** (algebraic) sum of e.m.f.(s) and p.d.(s) is zero	**M1**
	around a loop/around a <u>closed</u> circuit	**A1**
(b)(iii)	$4.0 = 1.8 + [2.0 \times (0.35 + R)]$ **or** $4.0 = 2.0 \times (0.90 + 0.35 + R)$	**C1**
	$R = 0.75\ \Omega$	**A1**

Q11.

(a)	sum of current(s) in = sum of current(s) out **or** (algebraic) sum of current(s) is zero	**M1**
	at a junction (in a circuit)	**A1**
(b)(ii)	E = 2.4 + 2.4 + 1.2	**C1**
	= 6.0 V	**A1**
	or	
	total resistance = 10 (Ω)	**(C1)**
	$E = 10 \times 0.60$ = 6.0 V	**(A1)**

Q12.

(c)(i)	180 Ω and 90 Ω resistors shown connected in parallel	**B1**

Q13.

(b)(i)	90 Ω and 45 Ω resistors shown connected in parallel	**B1**

Q14.

(a)	$I = I_1 + I_2 + I_3$	**B1**
	$(V / R) = (V / R_1) + (V / R_2) + (V / R_3)$ **or** $(I / V) = (I_1 / V) + (I_2 / V) + (I_3 / V)$ **and** $1 / R = 1 / R_1 + 1 / R_2 + 1 / R_3$	**B1**
(b)(i)	current = 0.49 + 0.45 = 0.94 A	**A1**

Q15.

(a)	sum of e.m.f.(s) = sum of p.d.(s)	**M1**
	around a loop/around a closed circuit	**A1**
(b)(i)	**1.** $1 / R = 1 / R_1 + 1 / R_2$ $1 / R = 1 / 90 + 1 / 18$	**C1**
	R = 15 Ω	**A1**
	2. $I = V / R$	**C1**
	$I = 4.8 / 15$ **or** $I = 4.8 / 90 + 4.8 / 18$ I = 0.32 A	**A1**
(c)	$7.2 – 5.6 – 2.5I – 3.5I = 0$	**C1**
	I = 0.27 A	**A1**

Q16.

(c)(ii)	**1.** $V_Y = 15 \times 10^{-3} \times 60$ (= 0.90 V)	**C1**
	$V_X = 2.0 - 0.90 - 0.75$ (= 0.35 V)	**C1**
	$R_X = 0.35 / (15 \times 10^{-3})$ $= 23\ \Omega$	**A1**
	or	
	total $R = 60 + 50 + R_X$	**(C1)**
	$60 + 50 + R_X = 2.0 / (15 \times 10^{-3})$	**(C1)**
	$R_X = 23\ \Omega$	**(A1)**
	2. $P = VI$ **or** $P = EI$ **or** $P = I^2R$ **or** $P = V^2 / R$	**C1**
	ratio $= \frac{(15\times10^{-3})^2 \times 60}{2.0\times15\times10^{-3}}$ **or** $\frac{0.90\times15\times10^{-3}}{2.0\times15\times10^{-3}}$ **or** $\frac{(0.90^2/60)}{2.0\times15\times10^{-3}}$ $= 0.45$	**A1**

Q17.

(a)	sum of current(s) into junction = sum of current(s) out of junction **or** (algebraic) sum of current(s) at a junction is zero	**B1**
(c)(ii)	(I =) 9.3 – 7.5	**C1**
	I = 1.8 (mA) **or** 1.8×10^{-3} (A) $R = 0.90 / 1.8 \times 10^{-3}$ $= 500\ \Omega$	**A1**
	or	
	total resistance = $0.90 / 9.3 \times 10^{-3} = 96.8\ (\Omega)$ total resistance of diode and X = $0.90 / 7.5 \times 10^{-3} = 120\ (\Omega)$ $1 / 96.8 = 1 / R + 1 / 120$	**(C1)**
	$R = 500\ \Omega$	**(A1)**

Q18.

(a)(i)	sum of current(s) into junction = sum of current(s) out of junction **or** (algebraic) sum of current(s) at a junction is zero	**B1**
(a)(ii)	charge	**B1**
(b)(ii)	$I_X = 3.0 / 15 = 0.20$ (A)	**C1**
	$I_Y = 2.5 - 0.20 = 2.3$ (A)	**C1**
	$R_Y = 3.0 / 2.3$ $= 1.3\ \Omega$	**A1**
	or	
	$R_T = 3.0 / 2.5 = 1.2\ (\Omega)$ **or** $(8.0 / 2.5) - 2.0 = 1.2\ (\Omega)$	**(C1)**
	$1/1.2 = 1/15 + 1/R_Y$	**(C1)**
	$R_Y = 1.3\Omega$	**(A1)**

Q19.

(a)	sum of e.m.f.(s) equal to sum of p.d.(s)	**M1**
	around a loop/around a closed circuit	**A1**
(b)(i)	current in variable resistor = (6.0 / 2.4) + (6.0 / 1.2) (= 7.5 A)	**C1**
	p.d. across variable resistor = 9.0 – 6.0 (= 3.0 V)	**C1**
	R = 3.0 / 7.5 = 0.40 Ω	**A1**
	or	
	$\frac{1}{R_T} = \frac{1}{2.4} + \frac{1}{1.2}$ R_T = 0.80 (Ω)	**(C1)**
	$\frac{3}{9} = \frac{R}{(R + 0.80)}$ **or** $\frac{3}{R} = \frac{6}{0.8}$	**(C1)**
	R = 0.40 Ω	**(A1)**

Q20.

(b)(ii)	R = 1.4 / 0.50 = 2.8 Ω	**A1**