Resistor Network Answers

1. (a) pd = 3.6 V **(1)** 1

Example of answer;
p.d. = 0.24 A × 15 Ω = 3.6 V

(b) Calculation of pd across the resistor **(1)**
[6.0 – 3.6 = 2.4 V]
Recall V = I_R **(1)**
I_1 calculated from their pd / 4Ω **(1)**

[correct answer is 0.60 A. Common ecf is 6V/4Ω gives 1.5 A] 3

Example of answer:
I_1 = 2.4 V / 4.0 Ω = 0.6 A

(c) Calculation of I_2 from I_1 – 0.24 [0.36 A] **(1)**
[allow ecf of their I_1. common value = 1.26 A]
Substitution V = 3.6 V **(1)**
R = 10 Ω **(1)** 3

[7]

2. (a) p.d. across 4 Ω resistor

1.5 (A) × 4 (Ω)

= 6 V **(1)** 1

(b) Resistance R_2

Current through R_2 = 0.5 A **(1)**

$R_2 = \frac{6\,(V)}{0.5(A)}$

R_2 = 12 Ω **(1)** 2

[allow ecf their pd across 4 Ω]

(c) Resistance R_1

p.d. across R_1 = 12 − 6 − 4

= 2 V **(1)**

Current through R_1 = 2 A **(1)**

$R_1 = \frac{2(V)}{2(A)}$ = 1Ω **(1)**

[allow ecf of pd from (a) if less than 12 V]

Alternative method

Parallel combination = 3Ω **(1)**

Circuit resistance = 12(V)/2 (A) = 6Ω **(1)**

R_1 = 6 – (3 + 2) = 1 Ω **(1)** 3

[allow ecf of pd from (a) and R from (b)]

[6]

3. Charge

Charge is the current × time **(1)** 1

Potential difference

Work done per unit charge [flowing] **(1)** 1

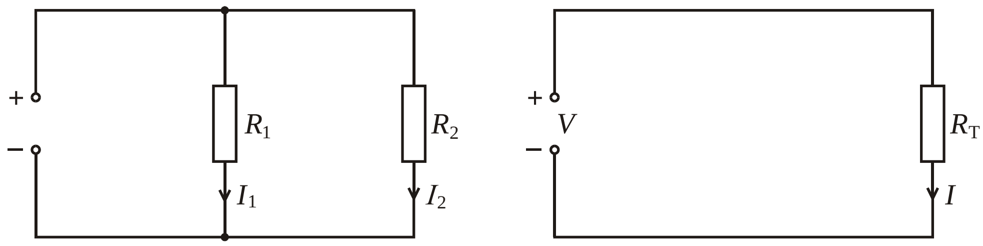
Energy

9 V × 20 C **(1)**

= 180 J **(1)** 2

[4]

4. The power supplies in the two circuits shown below are identical.



Write down the relationship between I_1, I_2 and I which must hold if the combined resistance of the parallel pair, R_1, and R_2, is to equal R_T.

$I = I_1 + I_2$

(1 mark)

Hence derive the formula for the equivalent resistance of two resistors connected in parallel.

From Ohm's law:

$I = V/R_T$ $\quad I_1 = V/R_1$ $\quad I_2 = V/R_2$ **(1)**

$\therefore V/R_T = V/R_1 + V/R_2$ **(1)**

and $1/R_T = 1/R_1 + 1/R_2$ **(1)**

(3 marks)

Use your formula to show that the resistance between the terminals of a low-resistance component is hardly changed when a high-resistance voltmeter is connected in parallel with it.

If $R_V >> R_{low}$ **then** $1/R_V >> 1/R_{low}$ **(1)**

and $R_T \approx R_{low}$ **(1)**

Allow method based on numerical example

(2 marks)
[Total 6 marks]

5. Resistance calculations

Evidence of 20 Ω for one arm **(1)**

$\frac{1}{R} = \frac{1}{20} + \frac{1}{20}$ **(1)**

R = 10 Ω **(1)** 3

Comment

This combination used instead of a single 10 Ω resistor [or same value as before] **(1)**

because a smaller current flows through each resistor/reduce heating in any one resistor/average out errors in individual resistors **(1)** 2

[5]

6. Circuit

Ammeters and two resistors in series **(1)** 1

[1 mark circuit penalty for line through cell or resistor]

Cell e.m.f

E= 150 x 10^{-6} (A) x 40 x 10^{3} (Ω) total R **(1)**

Powers of 10 **(1)** 2

E = 6.0 (V)

New circuit

Voltmeter in parallel with 25 (kΩ) resistor **(1)** 1

Resistance of voltmeter

(Total resistance) = $\frac{6\text{(V)}}{170 \times 10^{-6}\text{(A)}}$

= (35.3 kΩ) **(1)**

(Resistance of ll combination) = 35 – 15 kΩ

= (20 Ω) [e.c.f. their total resistance] **(1)**

$\frac{1}{20} = \frac{1}{25} + \frac{1}{R_V}$

$\frac{1}{R_V} = \frac{5-4}{100}$

R_V = 100 kΩ [108 kΩ if R_T calculated correctly] **(1)**

Alternative route 1: 3

p.d. across 15 kΩ = 2.55 V **(1)**

($\therefore$ p.d. across ll combination = 3.45 V)

resistance combination = 20 kΩ **(1)**

$\rightarrow R_V$ = 100 kΩ **(1)**

[7]

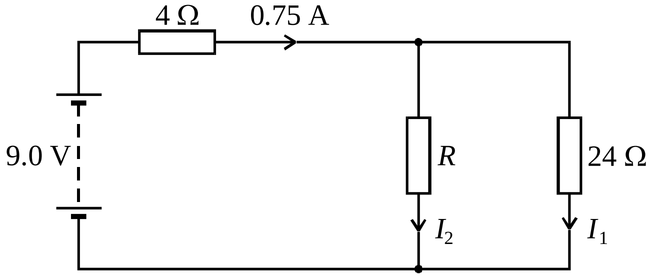
Alternative route 2: 3

p.d. across parallel combination = 3.45 V **(1)**

I through 25 kΩ = 138 μA **(1)**

$\rightarrow R_V$ = 100 kΩ **(1)**

7. The circuit shows a battery of negligible internal resistance connected to three resistors.



Calculate current I_1.

Voltage drop across 4Ω resistor = 3V (1)

$$I_2 = \frac{(9\text{ V} - 3\text{ V})}{24\ \Omega} \quad \textbf{(1)}$$

I_1 = 0.25 A (1)

(3 marks)

Calculate resistance R

I_2 = 0.75 A – 0.25 A = 0.50 A (1)

R = 6 V / 0.50 A = 12 Ω (1)

R = 12 Ω

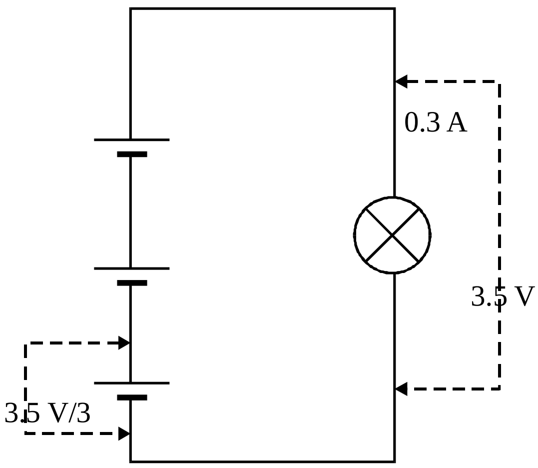
(2 marks)
[Total 5 marks]

8. Diagram of torch circuit:

The lamp will light

Correct circuit 2

[Circuit showing one cell only is allowed one mark only unless the cell is labelled 4.5 V. If a resistor is included, allow first mark only unless it is clearly labelled in some way as an internal resistance.]



Voltage across each circuit component and current in lamp:
Either 3.5 V/3 shown across the terminals of one cell or 3.5 V across all three cells
3.5 V shown to be across the lamp
0.3 A flowing in the lamp [i.e. an isolated 0.3 A near the lamp does not score] 3
Calculation of internal resistance of one of the cells:

Lost volts = 4.5 V - 3.5 V *or* 1.5 V – $\frac{3.5\text{V}}{3}$

or total resistance = (4.5 V)/0.3 A) = 15 KΩ

Internal resistance of one cell = [(1.0 V)/(0.3 A)] ÷ 3

or [(0.33 V) (0.3 A)] *or* lamp resistance = (3.5 V) / (0.3 A)11.7 Ω
= 1.1 Ω *or* = (3.3Ω)/3 = 1.1 Ω 3

[Some of these latter marks can be read from the diagram if it is so labelled]

[8]

9. Proof:

$V = V_1 + V_2$	$V = V_1 + V_2$	**(1)**
$V = IR$ $V_1 = IR_1$ $V_2 = IR_2$	$\div I$	**(1)**
Substitute **and** cancel I	Sub using R =	**(1)**
		3

Explanation of why it is a good approximation:

Resistance of connecting lead is (very) small **(1)**

So $I \times R_{\text{(very) small}}$ = (very) small p.d./e^{-1}s do little work so p.d. small/r small compared with rest of the circuit so p.d. small **(1)**

2

Circumstances where approximation might break down:

If current is large **OR** resistance of rest of circuit is small **(1)**

[**Not** high voltage/long lead/thin lead/high resistivity lead/hot lead]

1

Calculation:

Use of $R = \frac{\rho l}{A}$ with A attempted × sectional area **(1)**

Correct use of 16 **(1)**

Use of $V = IR$ **(1)**

0.036 V **(1)**

4

[10]

10. <u>No</u>, because *V* is not proportional to *I* OR not straight line through origin / **(1)**
only conducts above 0.5 V / resistance changes 1

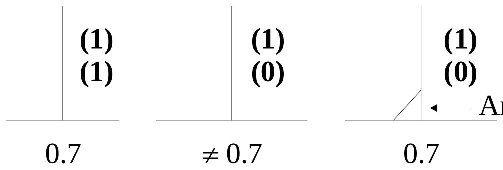
Use of *R* = 0.74 / current from graph **(1)**

= 9.25 Ω [9.0 – 9.5 Ω] [Minimum 2 significant figures] **(1)** 2

Calculation of p.d. across *R* [8.26]	Calculation of total resistance[109 – 115]	Ratio *R*: ratio *V*	*E* = *ΣIR* **(1)**
÷ *I*	– diode resistance [9]	Correct substitutions	Correct substitutions **(1)**
103 Ω [100 – 106] **(1)**			

3

[If not vertical line, 0/2]



Anything (gap, curve, below axis) **(1)(1)** 2

[Otherwise **0 0**]

[8]

11. <u>Circuit diagram</u>

Resistor with another variable resistor/potential divider/variable power pack **(1)**

Ammeter reading current through resistor **(1)**

Voltmeter in parallel with resistor **(1)** 3

<u>Graph labels</u>

Straight line – resistor }
Curve – lamp } Both labelled **(1)** 1

<u>Potential difference</u>

At 0.5 A p.d.= 3.5 V / 3.4 V + 7.8 V / idea of adding p.d. [for same current] **(1)**

= 11.2 V/11.3 V **(1)** 2

[Accept 11.0 –11.5 V]

<u>Resistance of lamp</u>

$\frac{3.5\text{ V}}{0.5\text{ A}}$ [OR their value of p.d. across lamp ÷ 0.5 A] **(1)**

= 7.0 Ω **(1)** 2

[e.c.f. their value]

[8]

12. Show that
[In diagram or text}

- states p.d. same across each resistor **(1)**
- use of $I = I_1 + I_2 + I_3$ [symbols or words] **(1)**
- $\frac{V}{R} = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}$ **(1)** 3

[$I = V / R$ stated somewhere gains one mark]

Networks

First network:	2.5(Ω) **(1)**	
Second network:	25 (Ω) **(1)**	
Third network:	10 (Ω) **(1)**	3

Meter readings

Ammeter:	25 (mA) **(1)**	
Voltmeter V_1:	25 × 10 OR 50 × 5 [ignore powers of 10] **(1)**	
= 0.25 V **(1)**		
Voltmeter V_2:	50 × 25 [ignore powers of 10] **(1)**	
= 1.25 V **(1)**		5

[Allow full e.c.f. for their resistance for 2nd network OR their V_1 answer]

[11]

13. Readings on voltmeter

Use of any resistor ratio OR attempt to find current in *either* circuit **(1)**

At 950 kΩ

$V = \frac{10\,\text{k}\Omega \times 6\,\text{V}}{960\,\text{k}\Omega}$ = 0.063 V **(1)**

At 1.0 kΩ

$V = \left(\frac{10\,\text{k}\Omega \times 6\,\text{V}}{11\,\text{k}\Omega}\right)$ = 5.45 V **(1)** 3

Use of circuit as lightmeter

Maximum resistance corresponds to low light intensity/resistance down as light intensity up **(1)**

∴ lightmeter or voltmeter reading will increase as light intensity increases [or reverse] **(1)** 2

[Can ecf for 2nd mark if resistance/light intensity incorrect and/or p.d. calculation wrong]

[5]