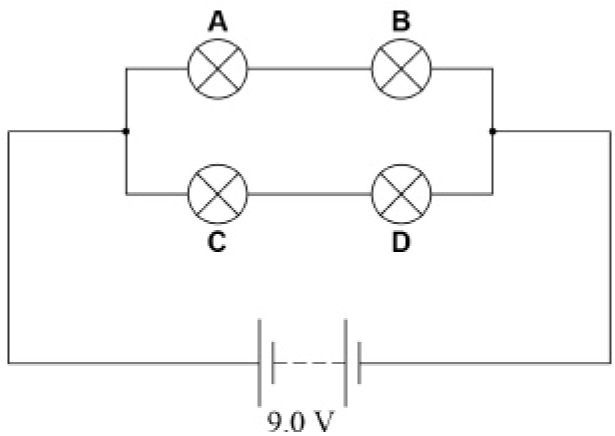
1 A student connects four lamps **A**, **B**, **C** and **D** in the circuit shown in **Figure 1**.
The battery has an emf of 9.0 V and negligible internal resistance.

Figure 1



(a) The table shows the operating conditions for the lamps when they are at normal brightness.

Lamps	Operating voltage / V	Power / W
A and **C**	6.0	6.0
B and **D**	3.5	4.1

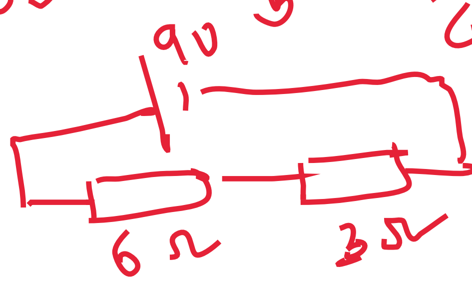
The student observes that **two** of the lamps are at their normal brightness.
Assume that any changes in resistance of the lamps are negligible.

Determine which **two** lamps are at their normal brightness.

Use calculations to support your answer.

$R_A = \frac{V^2}{P} = \frac{6^2}{6} = 6\Omega$ $R_B = \frac{3.5^2}{4.1} = 3\Omega$

each loop =



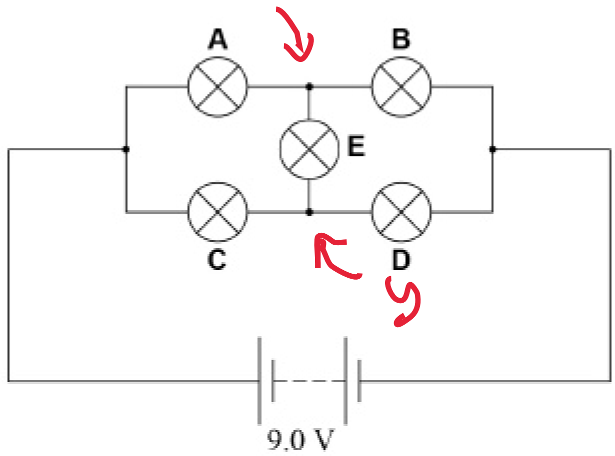
$\therefore V_A = \frac{6}{9} \times 9 = 6V$ so A&C normal

$V_B = 3V$ so B&D below operating pd

(4)

(b) The student connects another lamp **E** in the circuit as shown in **Figure 2**.
Lamp **E** is identical to lamps **A** and **C**.

X **Figure 2**



Explain what the student would observe regarding the brightness of the lamps.

Refer to potential differences across lamp **E** in your answer.

p.d. at X = 3V
p.d. at y = 3V
∴ p.d. across E = 0V
So E doesn't light & has no current
Other bulbs unaffected

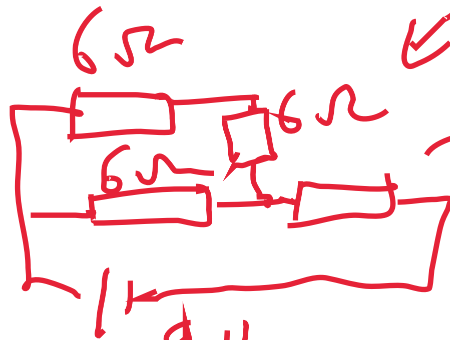
(3)

(c) Lamp **B** in **Figure 2** fails so that it no longer conducts. This change does not affect the resistance of the other lamps.

Deduce the effect on the current in the battery.

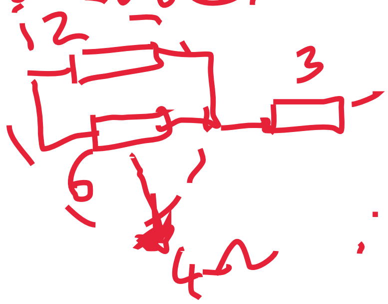
Use calculations to support your answer.

reduce to 1 res.



So we now have:

which is:



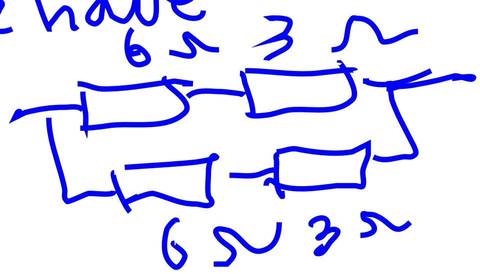
∴ $R_T = 7\Omega \Rightarrow I = \frac{9}{7} = 1.29 A$

So now compare with Fig all working. We can ignore E since no I flows through it.

(3)

(Total 10 marks)

so we have



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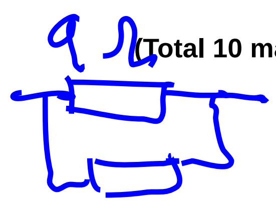

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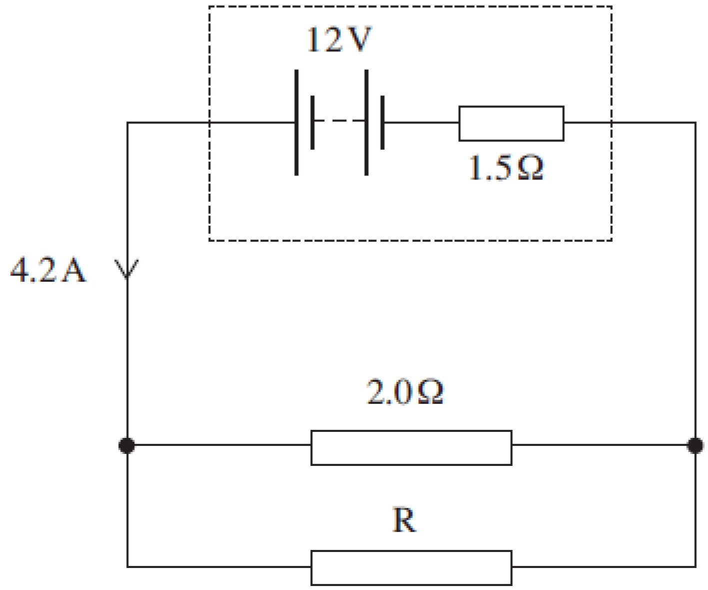
∴ $I = \frac{9}{4.5} = 2A$

So when B breaks, current reduces from 2A to 1.3A

2 The circuit diagram below shows a battery of electromotive force (emf) 12 V and internal resistance 1.5 Ω connected to a 2.0 Ω resistor in parallel with an unknown resistor, R. The battery supplies a current of 4.2 A.



(a) (i) Show that the potential difference (pd) across the internal resistance is 6.3 V.

$V = IR \Rightarrow 4.2 \times 1.5 = 6.3$

(1)

(ii) Calculate the pd across the 2.0 Ω resistor.

$12 - 6.3 = 5.7V$

pd ____________________ V

(1)

(iii) Calculate the current in the 2.0 Ω resistor.

$I = V/R = 5.7/2$

current ____2.85____ A

(1)

(iv) Determine the current in R.

$4.2 - 2.85$ 1.35

current ____1.35____ A

(1)

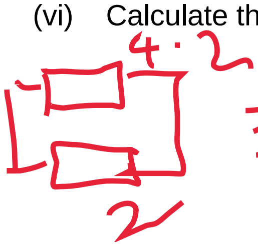
(v) Calculate the resistance of R.

$R = \frac{V}{I} = \frac{5.7}{1.35}$

R ___4.2___ Ω

(1)

(vi) Calculate the total resistance of the circuit.



$= 1.35\Omega$ $R_T = 1.35 + 1.5$

circuit resistance ___2.85___ Ω

(2)

(b) The battery converts chemical energy into electrical energy that is then dissipated in the internal resistance and the two external resistors.

(i) Using appropriate data values that you have calculated, complete the following table by calculating the rate of energy dissipation in each resistor.

resistor	rate of energy dissipation / W
internal resistance	$P = I^2R = 4.2^2 \times 1.5$ 26.46
2.0 Ω	$P = I^2R = 2.85^2 \times 2$ 16.25
R	$P = 1.35^2 \times 4.2$ 7.65

(3)

(ii) Hence show that energy is conserved in the circuit.

Total power dissipated in Resistors (as heat)

= 50.36 W

(2)

(Total 12 marks)

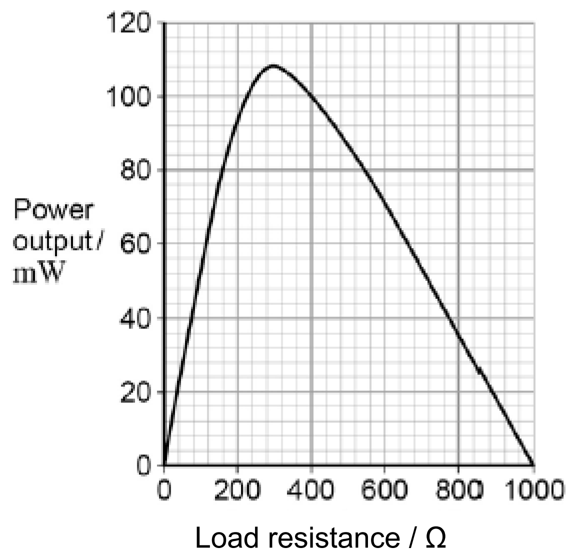
Power supplied = PV = 4.2 × 12

= 50.4 W

So both same

3 **Figure 1** shows data for the variation of the power output of a photovoltaic cell with load resistance. The data were obtained by placing the cell in sunlight. The intensity of the energy from the Sun incident on the surface of the cell was constant.

Figure 1



(a) Use data from **Figure 1** to calculate the current in the load at the peak power.

Peak load at R = 300Ω (graph)

which is at 107mW

$P = I^2R \Rightarrow \sqrt{\frac{107mW}{300\Omega}} = I$

0.0189 A

(3)

(b) The intensity of the Sun's radiation incident on the cell is 730 W m^{-2}. The active area of the cell has dimensions of 60 mm × 60 mm.

Calculate, at the peak power, the ratio $\frac{\textit{electrical energy delivered by the cell}}{\textit{energy arriving at the cell from the Sun}}$

Area $= (60 \times 10^{-3})^2 = 3.6 \times 10^{-3}\ m^2$

so of 730 on $1\ m^2$ we have $3.6 \times 10^{-3} \times 730$

$= 2.63\ W$

ratio $= \frac{107\ mW}{2.63\ W} = 4.1 \times 10^{-2}$

(3)

(c) The average wavelength of the light incident on the cell is 500 nm. Estimate the number of photons incident on the active area of the cell every second.

$c = f\lambda$

$\lambda = 500\ nm$

$E = hf \Rightarrow \frac{h \times c}{\lambda}$

$= 3.96 \times 10^{-19}\ J$

we need $\frac{2.63}{3.96 \times 10^{-19}}$ photon

$= 6.6 \times 10^{18}$

(2)

(d) The measurements of the data in **Figure 1** were carried out when the rays from the sun were incident at 90° to the surface of the panel. A householder wants to generate electrical energy using a number of solar panels to produce a particular power output.

Identify **two** pieces of information scientists could provide to inform the production of a suitable system.

(2)

(Total 10 marks)