AREA 2 – Electric power

The 60-watt light bulb in Sam's desk lamp has burnt out. There is no spare replacement that operates on the 240-V supply. However, a 60-watt light bulb is found that operates at 120 V. Sam suggests building the following circuit in order to use the 120-V light bulb.

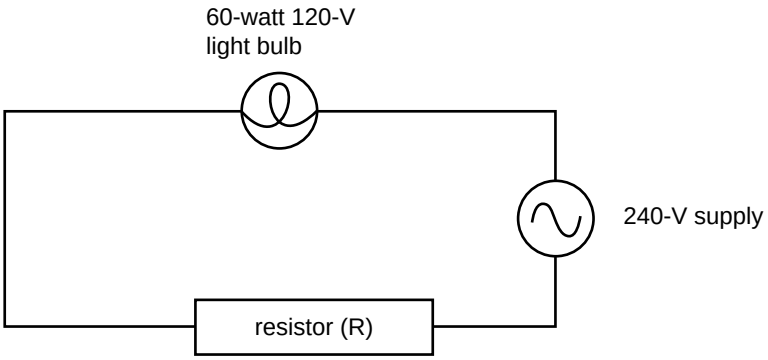


Figure 1

Question 1

What is the value of the resistor R that will allow the 120-V light bulb to operate correctly?

ohm

3 marks

Sometimes strings of Christmas-tree lights consist of three groups of globes that are connected as shown in Figure 3.

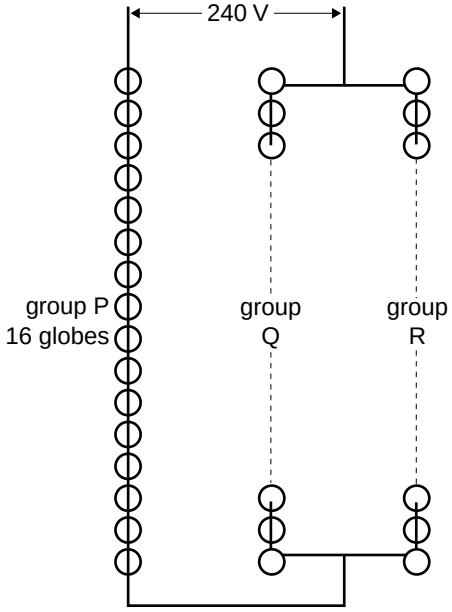


Figure 3

There are 16 globes in group P. Each of the globes has a voltage of 10 V across it and a current of 0.50 A flowing through it when the string of lights is operating as designed. The globes in groups Q and R have a different power rating to those in group P.

The number of globes in groups Q and R is equal. Although they have a different power rating from the globes in group P, the potential difference across each globe is still 10 V when operating.

Question 5

How many globes are there in group Q?

2 marks

Question 6

What current is being supplied from the electricity supply to the string of lights?

A

2 marks

Assume that the power rating of all globes in Q and R are identical.

Question 7

How much power is dissipated by each globe in groups Q and R?

W

3 marks

One of the globes in group Q burns out.

Question 8

Indicate in the box beside each group whether the globes in that group are on or off. **If the group is on**, indicate whether the globe is **brighter** or **dimmer** compared to when the system is operating correctly.

Group	ON/OFF	Brightness
P		
Q		
R		

3 marks

AREA 2 – Electric power

The electric power for Melbourne trams is supplied at a DC voltage of 600 V. The current flows from the overhead wire through the tram motor and returns through the metal rails. Because of the voltage drop that occurs in the overhead wire, the wire is made up of separate 3.0-km sections. One of these sections is shown in Figure 1. A separate 600-V supply is connected to **one end only** of each section.

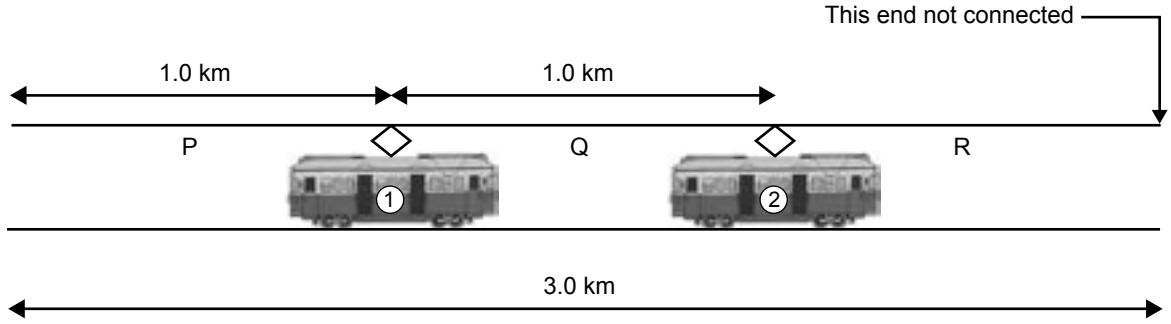


Figure 1

Tram 2 is accelerating and is drawing a current of 500 A. Tram 1 is drawing a current of 200 A.

Question 1

What is the current in sections P, Q and R of the wire?

P	A
Q	A
R	A

3 marks

The voltage at the position of tram 2 is 540 V.

Question 2

How much electrical power is tram 2 using?

W

2 marks

Question 3

What is the resistance of 1.0 km of the overhead wire?

Ω

3 marks

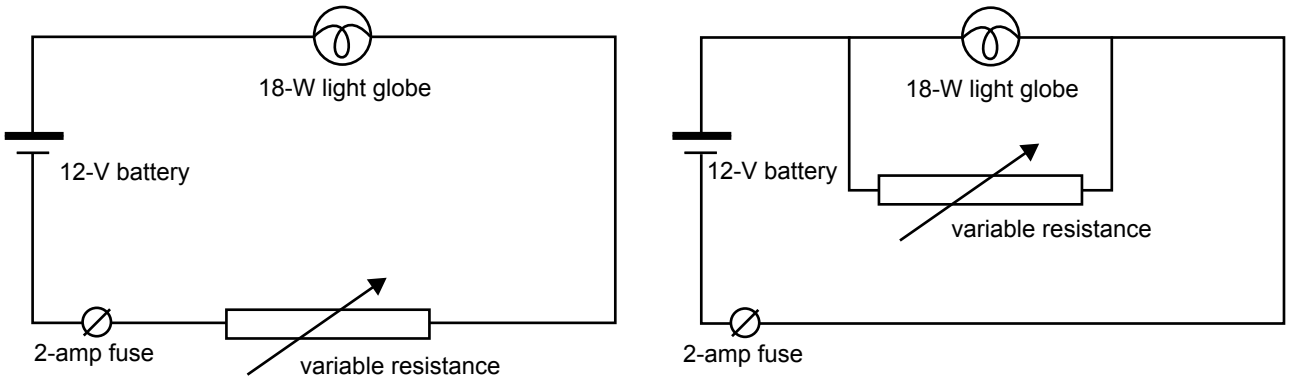
Question 4

What is the voltage at the position of tram 1?

V

3 marks

Kim decides to design a circuit to control the light intensity of a portable lamp. The circuit consists of a 12-V light globe rated at 18 W, a variable resistor, a 12-V battery, and a 2-amp fuse with negligible resistance. Kim is considering two different circuits, shown in Figure 2 as circuit A and circuit B.



circuit A **circuit B**

Figure 2

When the variable resistance in circuit A is zero, or when the variable resistance in circuit B is infinite, the light globe operates at its rated value. The resistance of the filament is 8.0 Ω, and can be assumed to be independent of its temperature.

Question 5

Using circuit A, what is the value of the variable resistance when the power dissipated in the light globe is 9.0 W?

Ω

3 marks

Question 6

When using circuit B, what is the value of the variable resistance when the fuse burns out?

Ω

3 marks

Question 7

Which circuit, A or B, should Kim choose? Justify your answer.

3 marks

AREA 2 – Electric power

As a decoration for a party, Val purchased a set of 36 identical small, coloured globes connected in three strings each with 12 globes, as shown in Figure 1. The globes are designed to use the household 240 V_{RMS} supply.

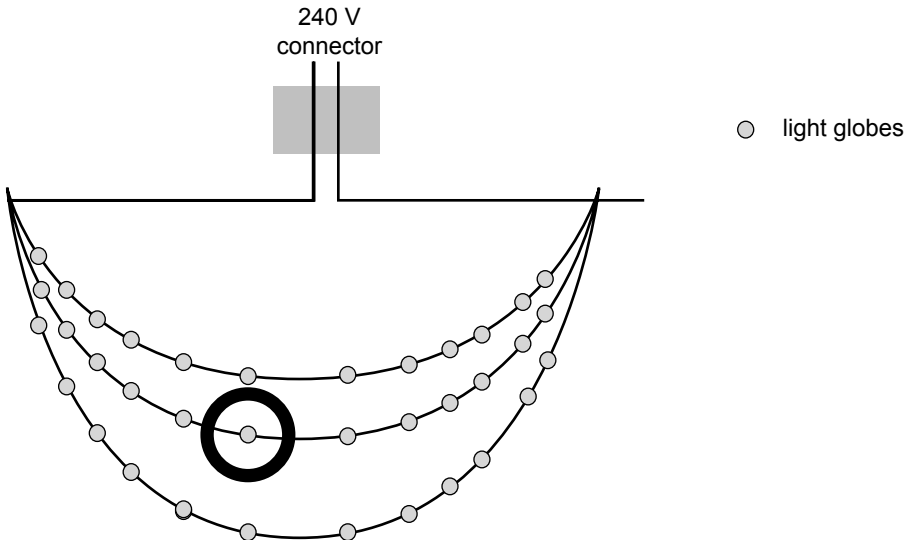


Figure 1

The claim on the box said that the power used when all the globes were lit was 48 W.

Question 1

What RMS current is drawn from the mains supply when all the globes are lit?

A

2 marks

Question 2

What current is flowing through **the globe with the circle round it**, when all the globes are lit?

A

2 marks

Question 3

What is the RMS voltage across each globe?

V

2 marks

Question 4

What is the power rating of each globe?

W

2 marks

On the box it stated that if one globe burnt out, the rest would continue to light. To Val, as a VCE physics student, this seemed strange. So as a test of this statement, Val removed the circled globe.

Question 5

Which of the statements below best describes the situation with the globe removed?

A. All the globes (except the one that is removed) remain lit.

B. The middle string does not light but the other two strings light as before.

C. The middle string does not light but the other two strings do, and are brighter than before.

D. None of the globes is lit.

2 marks

Area of Study 2 – Electronics and photonics

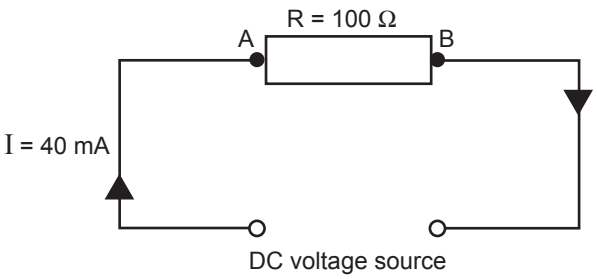


Figure 1

Figure 1 shows a resistor, a linear circuit component, with resistance R = 100 Ω.
A DC current, I = 40 mA, passes through this resistor in the direction shown by the arrows.

Question 1
What is the voltage drop across this resistor? Express your answer in volts.

V

2 marks

Question 2
Which one of the following statements (**A–D**) concerning the voltage across the resistor in Figure 1 is true?

A. The potential at point A is higher than at point B.
B. The potential at point A is the same as at point B.
C. The potential at point A is lower than at point B.
D. The potential at point A varies in sign with time compared to that at point B.

2 marks

Question 3
Determine the electrical energy dissipated in the 100 Ω resistor of Figure 1 in 1 second. In your answer provide the unit.

2 marks

In Figure 2, five identical 100 Ω resistors are used to construct a voltage divider. The voltage source across this voltage divider is an AC supply with an RMS voltage of 20 V. The resistors are labelled by the letters **A–E** as shown.

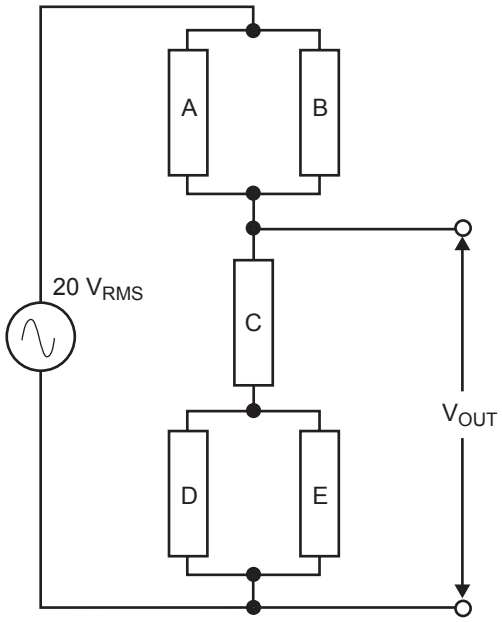


Figure 2

Question 4

What is the RMS output voltage, V_{OUT}?

V_{RMS}

3 marks

Question 5

Which one of the following statements (**A–D**) concerning the RMS currents in the circuit of Figure 2 is true?

A. The current in resistor A is identical to the current in resistor C.

B. The current in resistor D is twice the current in resistor C.

C. The current in resistor B is twice the current in resistor E.

D. The current in resistor A is identical to the current in resistor D.

2 marks

Use the following information to answer Questions 11–13.

Figure 5a

Bruce's garden has a pond with a fountain in it (as shown in Figure 5a). Bruce buys a floodlight to illuminate the fountain. The resistance of the floodlight filament is 3.0 Ω when operating.

Question 11

First Bruce tests the floodlight before he installs it. He tests it by applying 12 V_{RMS} across the floodlight.

What is the power used in the floodlight when supplied with a voltage of 12 V_{RMS}?

Show working.

W

3 marks

Bruce now installs the floodlight.

The electricity supply for the floodlight is supplied from the house using two wires (as shown in Figure 5b). Each of the two wires that connect the supply has a resistance of 0.50 Ω.

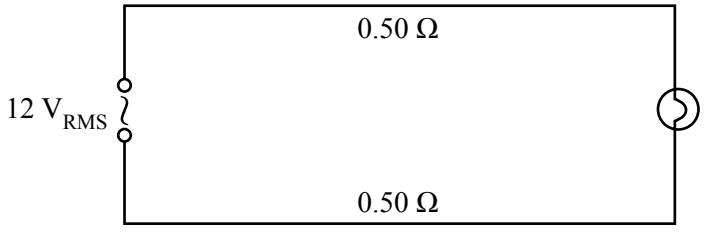


Figure 5b

Question 12

When operating, what is the voltage across the floodlight?

Show working.

V_{RMS}

3 marks

Bruce decides that the light is not bright enough and installs a second identical floodlight (as shown in the circuit below in Figure 5c).

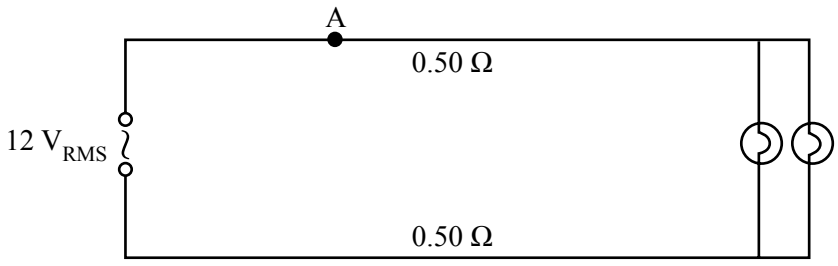


Figure 5c

Question 13

What is the current now flowing through the wire at point A?

Show working.

A

3 marks

Area of study 2 – Electronics and photonics

The following information relates to Questions 1–3.

Janelle sets up the circuit shown in Figure 1. The circuit consists of a 10 V battery and two resistors, R_1 = 40 Ω and R_2 = 30 Ω.

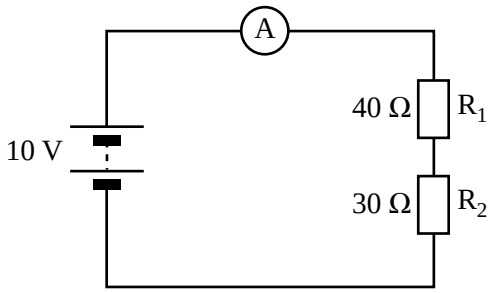


Figure 1

Question 1

What is the potential difference (voltage drop) across R_2?

V

2 marks

Question 2

What is the power dissipated in R_1?

W

3 marks

Janelle now adds a third resistor, $R_3 = 20\ \Omega$, as shown in Figure 2.

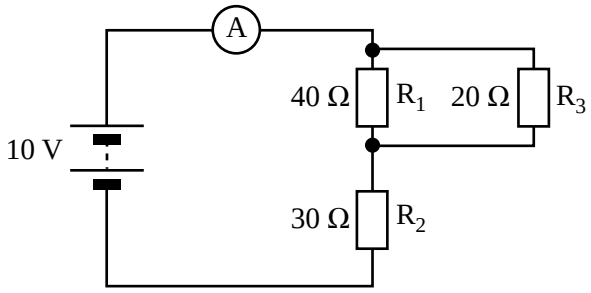


Figure 2

Question 3

What is the current through the ammeter A now?

A

3 marks

The following information relates to Questions 3 and 4.

Tom's teacher has given him

- two light globes (A and B) that each have a constant resistance of 2.0 Ω.
- two 0.50 Ω resistors
- a 24 V battery.

Tom connects up the circuit shown in Figure 4.

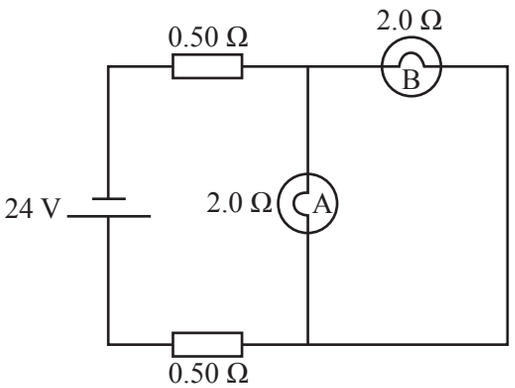


Figure 4

Question 3

Indicate the voltage (potential difference) across each of the globes.

light globe A	V
light globe B	V

2 marks

Question 4

What is the current drawn from the 24 V battery?

A

2 marks

Question 5

A particular device is used in a communications system to convert an electric signal into a light signal for transmission along an optical fibre.

The average voltage of the input signal is 10 V and the average current 10 mA.

The light beam output has a power of 50 mW.

The percentage efficiency of such a device is given by $\frac{\text{Power out}}{\text{Power in}} \times 100$.

What is the percentage (%) efficiency of the device?

%

2 marks

Area of study 2 – Electronics and photonics

The following information relates to Questions 1–4.

Four 2.0 ohm resistors (A, B, C and D) are connected as in Figure 1.

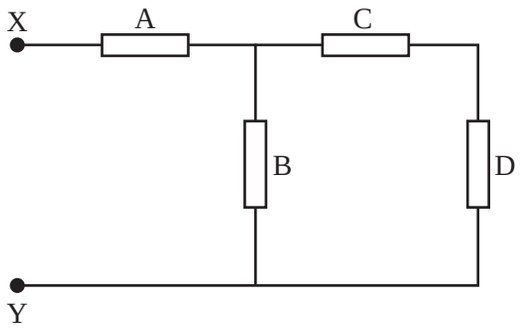


Figure 1

Question 1

Show that the total resistance of the circuit between X and Y is 3.3 ohm.

2 marks

Question 2

A 10 V battery is now connected across XY as shown in Figure 2.

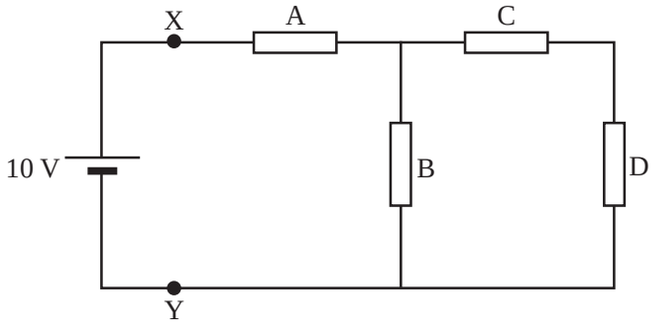


Figure 2

What is the current through resistor B?

A

2 marks

Question 3

What is the voltage drop (potential difference) across resistor A?

V

2 marks

Question 4

What is the power dissipated in resistor D?

W

2 marks

Question 18

Students are using a 12 V battery to power some lighting circuits. They connect the battery to each of the following two circuits shown in Figure 7 below. All the lights in both circuits are operating normally.

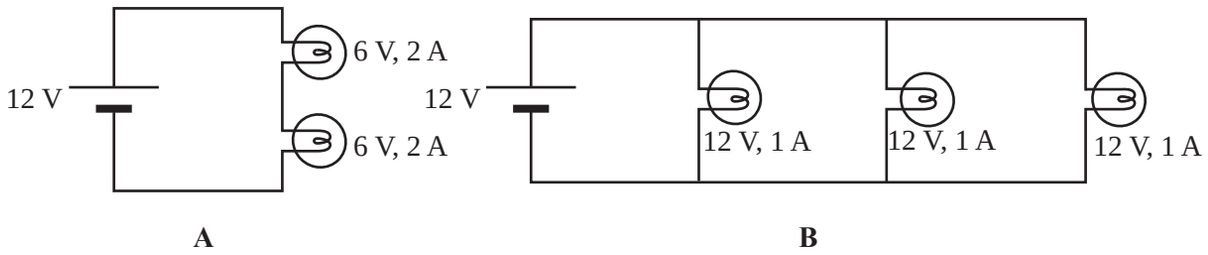


Figure 7

The students notice that one circuit requires more power from the battery than the other circuit.

Identify which of the circuits, A or B, uses more power and explain why this is the case, using numerical calculations in your answer.

3 marks

Area of study 2 – Electronics and photonics

Question 1

A resistor network is shown in Figure 1. All resistors have a value of 150 Ω.

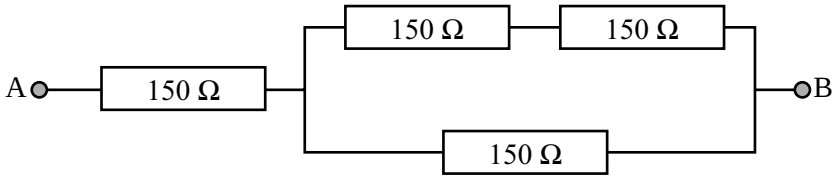


Figure 1

Calculate the resistance of the network between points A and B.

Ω

2 marks

Question 18 (16 marks)

Students are modelling the effect of the resistance of electrical cables, *r*, on the transmission of electrical power. They model the cables using the circuit shown in Figure 18.

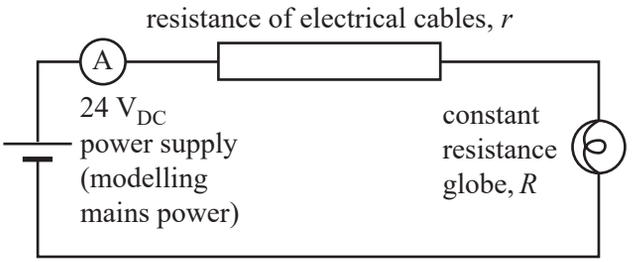


Figure 18

a. The 24 V_{DC} power supply models the mains power.

Describe the effect of increasing the resistance of the electrical cables, *r*, on the brightness of the constant resistance globe, *R*. 2 marks

The students investigate the effect of changing r by measuring the current in the electrical cables for a range of values. Their results are shown in Table 1 below.

Table 1

Resistance of cables, r (Ω)	**Current in cables, i (A)**	$\frac{1}{i}$ **(A^{-1})**
2.4	2.4	
3.6	2.0	
6.4	1.7	
7.6	1.5	
10.4	1.3	

b. Identify the dependent and the independent variables in this experiment. Give your reasoning. 2 marks

c. To analyse the data, the students use the following equation to calculate the resistance of the cables for the circuit.

$$r = \frac{24}{i} - R$$

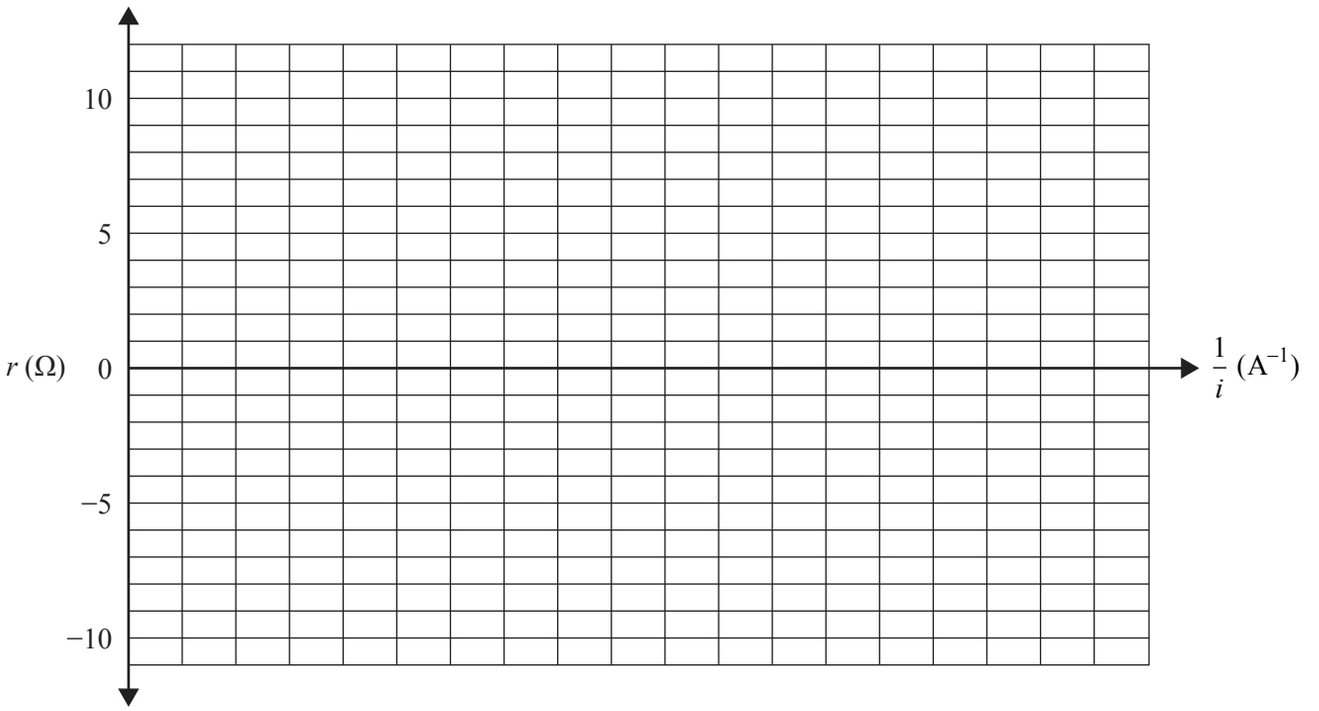
Show that this equation is true for the circuit shown in Figure 18. Show your working. 2 marks

d. Calculate the values of $\frac{1}{i}$ and write them in the spaces provided in the last column of Table 1. 2 marks

e. Plot a graph of r on the y-axis against $\frac{1}{i}$ on the x-axis on the grid provided below. On your graph:

- choose an appropriate scale and numbers for the x-axis
- draw a straight line of best fit through the plotted points
- include uncertainty bars (± x-direction only) of ±0.02 A^{-1}.
  (Uncertainty bars in the y-direction are not required.)

6 marks



f. Use the straight line of best fit to find the value of the constant resistance globe, R. Give your reasoning.

2 marks

Ω

END OF QUESTION AND ANSWER BOOK