Q1.
* Explain, with the aid of a circuit diagram, the method a student could use to investigate how the resistance of a single lamp changes with the potential difference across the lamp.

(6)

Q2.

A student investigates resistors connected in parallel using a number of resistors.
Each resistor has the same resistance.
Figure 10 shows a circuit diagram with one resistor, R.

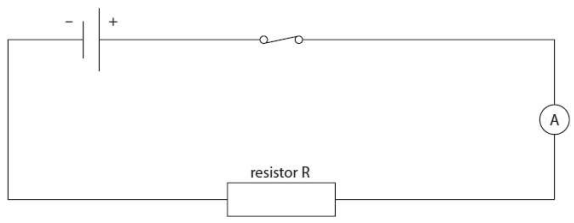


Figure 10

(i) Add to Figure 10:

- a voltmeter to find the potential difference across resistor R
- another resistor in parallel with resistor R.

(2)

(ii) State the measurements that the student must take to find the overall resistance of the resistors in parallel.

(2)

(iii) The student investigates how the overall resistance of the circuit changes when additional resistors are added in parallel to R.
Each resistor has the same resistance.
Figure 11 shows the results of the student's investigation.
State the resistance of a single resistor.

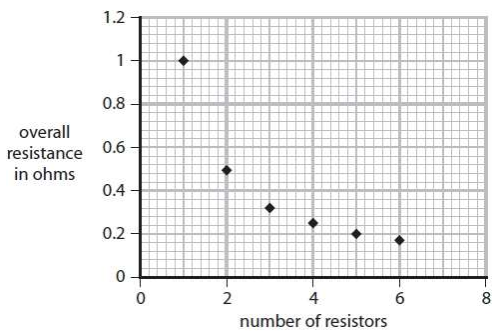


Figure 11

(1)

(iv) Comment on the relationship between the overall resistance of the circuit and the number of resistors in parallel.
Use information from Figure 11 to support your answer.

(3)

Q3.
The technician connects four devices to the car battery.
Each device is connected to its own switch and its own fuse.
Figure 9 shows how the four devices, fuses and switches are connected.
The current in each device is shown next to the device.

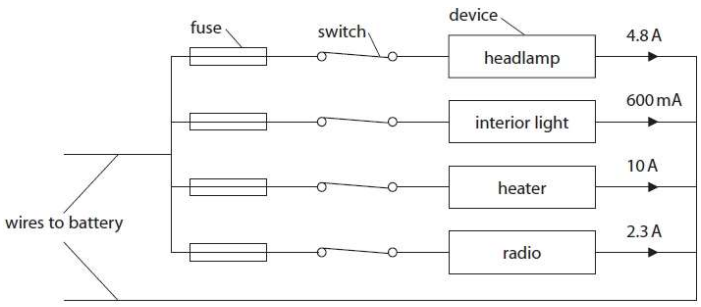


Figure 9

(i) Calculate the current in the wires to the battery when all the devices are switched on.

(1)

(ii) State how the overall resistance of the circuit changes when any one of the devices is switched off.

(1)

(iii) There is a current of 2.3 A in the radio when the radio is working correctly.

Which of these should the technician choose to protect the radio circuit?

(1)

- ☒ **A** 2 A fuse
- ☒ **B** 5 A fuse
- ☒ **C** 10 A fuse
- ☒ **D** 13 A fuse

(iv) Explain why the wires to the battery in a car are thicker than the wires that connect each device to its switch and its fuse.

(2)

Q4.
An electric heater is connected to a 230 V supply.
The power supplied to the heater is 2.6 kW.
Calculate the current in the heater.

(3)

Q5.
A different circuit is then set up with two resistors as shown in Figure 12.

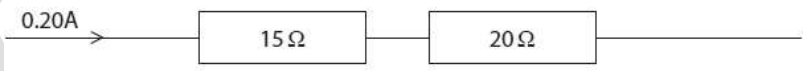


Figure 12

(i) Calculate the potential difference across the 15 Ω resistor.

(2)

(ii) Calculate the total power dissipated when there is a current of 0.20 A in the two resistors.
Use the equation $P = I^2 \times R$

(2)

Q6.
(i) The current in the element of the immersion heater is 14 A.
The power of the immersion heater is 130 W.
Calculate the resistance of the immersion heater.
Give your answer to two significant figures.

(3)

(ii) The current in the heating element of the kettle is 8.3 A.
State **two** differences between the movement of charge in the heating element of the kettle and the movement of charge in the immersion heater.

(2)

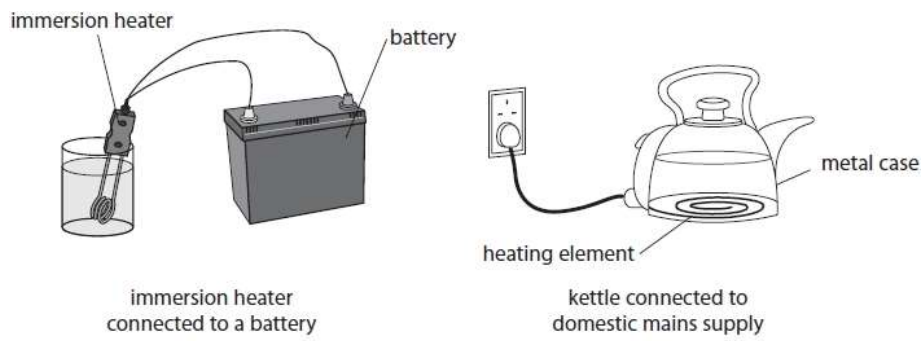


Figure 10

Q7.
Figure 1 shows a lamp connected to a d.c. power supply.
The power supply provides a potential difference (voltage) of 4.5 V.
The current in the lamp is 0.30 A.
(i) Calculate the resistance of the lamp.
Use the equation $R = \frac{V}{I}$

(1)

(ii) Calculate the power supplied to the lamp.

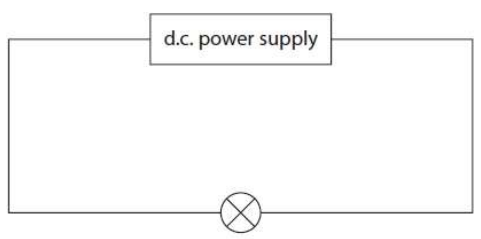


Figure 1

(2)

Q8.
A student investigates how the current in a lamp changes with the potential difference across the lamp.
The student uses the results to calculate the resistance of the lamp.

The results are shown in the table in Figure 2.

potential difference in V	current in A	resistance in Ω
1.0	0.09	11
2.0	0.14	14
3.0	0.18	17
4.0	0.22	18
5.0	0.26	
6.0	0.30	20

Figure 2

(i) One value of resistance is missing from the table in Figure 2. Calculate the value of resistance that is missing from the table.

(3)

(ii) The student writes this conclusion:
'The resistance of the lamp is directly proportional to the potential difference.'
Comment on the student's conclusion.
Use information from Figure 2 in your answer.

(3)

(iii) The student used a power supply that had fixed output voltage settings.
Each of these outputs was a whole number of volts.
Describe how the student could add a component to the circuit that would provide a continuously variable voltage across the lamp.

(2)

Q9.
Figure 23 shows an electric car connected to a battery charger.
The car has a rechargeable battery to drive its motor.
The rechargeable battery provides a potential difference of 330 V and can store up to 64 MJ.
It takes 8 hours for the battery to receive a full charge.
Assume that the charging process is 100% efficient.

(Source: © Danil Roudenko/123RF)

(a) Calculate the total charge that flows while the battery is being charged.

(3)

(b) Calculate the average charging current.

(3)

Q10.
The espresso machine shown in Figure 27 is an electrical appliance.
The espresso machine has an electrical heater connected to a 440 V mains supply. The power of the electrical heater is 3.5 kW.

(Source: © tanawaty/123RF)

(i) The rating of a fuse is the current above which it melts.
Which of these is the most suitable fuse for the espresso machine circuit?

(1)

- ☒ **A** 1 A
- ☒ **B** 5 A
- ☒ **C** 10 A
- ☒ **D** 13 A

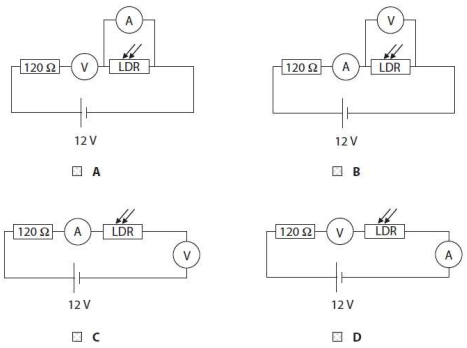
(ii) Before the espresso machine can be used, its heater must raise the temperature of some cold water.
The specific heat capacity of water is 4200 J/kg K.
Show that it takes the heater about 90 s to raise the temperature of 1 kg of water from 18°C to 95°C.
Use an equation from the formula sheet.

(3)

Q11.
Draw a circuit diagram you could use to investigate the relationship between potential difference, current and resistance for a filament lamp.

Q12.
(a) A technician investigates a light-dependent resistor (LDR) connected in series with a 120 Ω resistor and a voltage source.
The technician measures the voltage across the LDR and also the current in the LDR.
(i) Which **one** of these circuits should the technician use?
Put a cross (☒) in the box next to your answer.

(1)



(ii) When the LDR is in bright sunlight, its resistance is 185 Ω.
The voltage across the LDR is then 7.2V.
Show that the current in the LDR is about 0.039 A.

(2)

(iii) The current in the 120 Ω resistor is

(1)

- ☒ **A** much more than the current in the LDR
- ☒ **B** much less than the current in the LDR
- ☒ **C** the same as the current in the LDR
- ☒ **D** the opposite of the current in the LDR

(iv) The technician repeats the readings with the LDR in different light conditions.
The table gives two of the readings.

light condition	current in LDR
bright sunlight	0.039 A
cloudy skies	0.028 A

Explain why the two current readings are different.

(2)

*(b) The photograph shows a temporary traffic sign.
The traffic sign uses many small lights all powered by a rechargeable battery.
These lights need to be very bright during the day so that they can be seen clearly.
They do not need to be as bright at night.
Explain how using a light-dependent resistor can make the energy stored in the battery last longer.

(6)

Q13.
Figure 1 shows the results from an experiment where the potential difference (voltage) across a filament lamp was varied. The current and voltage were measured.

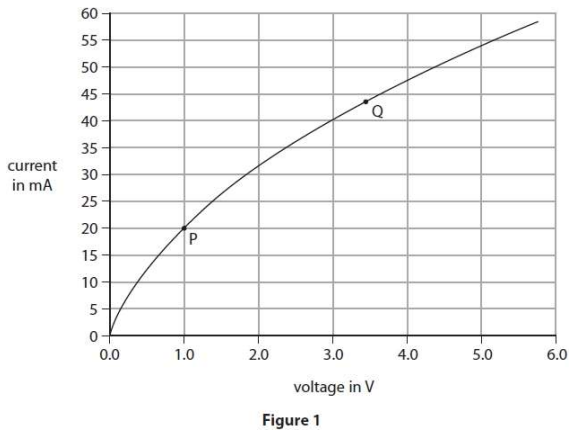


Figure 1

(i) Describe the relationship between the current and the voltage as shown in the graph in Figure 1.
(2)

(ii) Use the values of the voltage and current at point P and at point Q on the graph in Figure 1 to complete the table in Figure 2.
(2)

	voltage in V	current in mA
point P		
point Q		

Figure 2

(iii) Calculate the resistance of the filament lamp when the voltage is 4.5 V and the current is 51 mA.
Use the equation (2)

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

(iv) Explain why the resistance of the filament lamp changes as the voltage across it increases.
(3)

Q14.

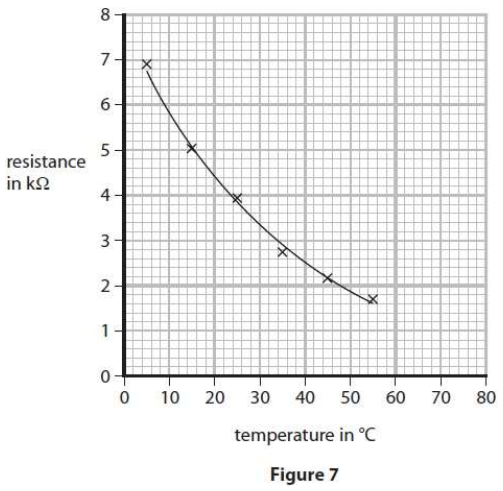


Figure 7

A student investigates how the resistance of a thermistor varies with temperature. Figure 7 shows a graph of the results of this investigation.
(i) Describe how the resistance of this thermistor varies with temperature.
(2)
(ii) Draw the tangent to the curve at a temperature of 30 °C, to find the rate of change of resistance with temperature at 30 °C.
State the unit. (3)

Q15.
A student is given a low voltage power supply and 1 m of resistance wire. The student uses these and other pieces of equipment to measure the resistance of just 50 cm of the resistance wire. Draw a diagram of the circuit that the student should use. Your circuit diagram should identify the pieces of equipment that the student uses. (3)

Q16.
A man monitors how much money he spends on electricity. He uses a device which calculates the cost of electrical energy used. He connects his 2.9 kW electric kettle to the 230 V mains supply.
(i) Calculate the current in the kettle element. (3)

(ii) The device shows that in one week the total cost of the electrical energy used by the kettle is 97 p.
1kW h of electrical energy costs 17 p. Calculate the length of time for which the kettle has been switched on during the week.
(3)

Q17.
A resistor is connected to a power supply.
The potential difference across the resistor is 6.0 V.
(i) Which of these corresponds to a potential difference of 6.0 V?
(1)

- ☒ **A** 6.0 joules per ohm
- ☒ **B** 6.0 amps per coulomb
- ☒ **C** 6.0 joules per coulomb
- ☒ **D** 6.0 amps per ohm

(ii) The resistor remains connected for a period of time. The current in the resistor is 200 mA.
A total charge of 42 C flows through the resistor. Calculate, in minutes, the time taken for this amount of charge to flow through the resistor.
(3)

(iii) Calculate the total energy transferred by the 6.0 V power supply when a charge of 42 C flows through the resistor.
(2)

Q18.
connect the kettle to the mains. A fault occurs in the kettle causing the
Explain how the safety features of the plug operate when this fault

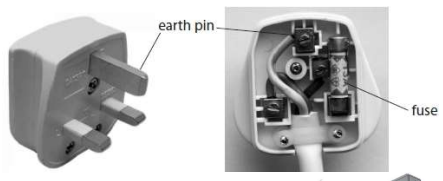


Figure 11 shows the three-pin plug used to live wire to touch the metal case of the kettle. occurs. (6)

Q19.
battery charger.


Fig
(Source: © Danil Roudenko/123RF)
Figure 23 shows an electric car connected to a

connected to the 230 V a.c. domestic mains supply. The output voltage of the charger * The battery charger shown in Figure 23 is is 335 V and it provides a d.c. charging current.
Charging stops if the charging current exceeds 15 A.
Explain how electrical components in the charger can be connected together to give this type of output.
(6)

Q20.
A student investigates how the resistance of a thermistor varies with temperature.

Figure 8 shows the apparatus used for this investigation.

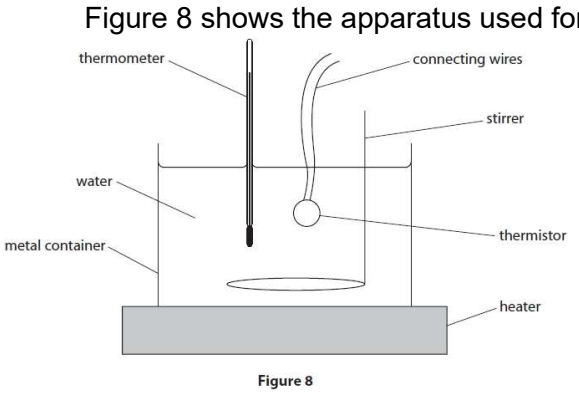


Figure 8

(i) Explain **one** improvement in measurement that the student could make in the investigation.

(2)

In this investigation, the resistance can be measured in two ways.
Method 1 – use an ohmmeter.
Method 2 – use an ammeter and a voltmeter.

(ii) Explain why method 2 gives more precise results than method 1. **(2)**

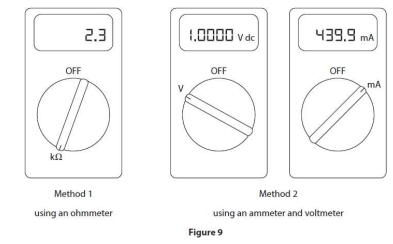


Figure 9

A

Q21.
resistor is connected to a power supply.
The resistor becomes warm while there is a current in it.
Explain why the resistor becomes warm.

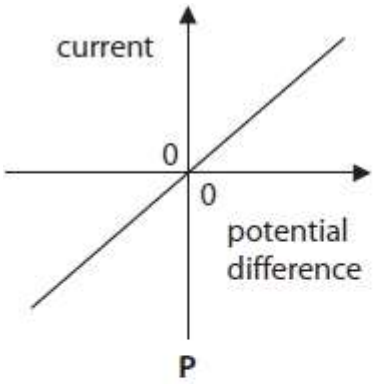
(2)

Q22.
Explain how current varies with potential difference for the component that matches graph R. Refer to the resistance of the component in your answer.

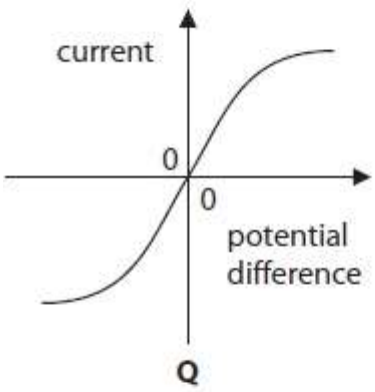
(3)

Q23.
The graphs P, Q and R in Figure 7 each show how the current in a component varies with the potential difference (voltage) across that component.
In each box, state the name of the component that matches the graph.

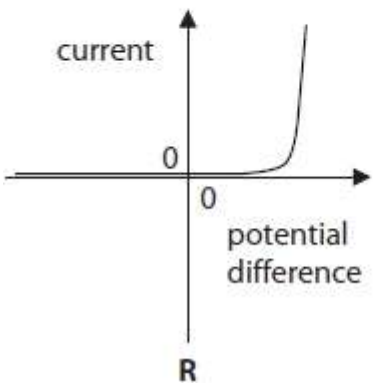
(3)



P



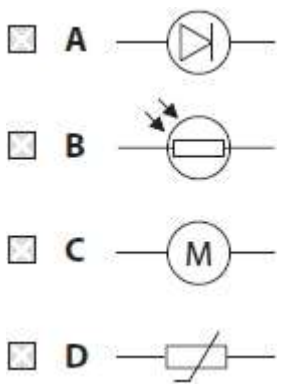
Q



R

Q24.
Which of these symbols is used to represent a thermistor in an electrical circuit?

(1)



Q25.

A student investigates how the resistance of a thermistor varies with temperature.

(a) The student sets up the circuit shown in Figure 5 to measure current and voltage.
He finds that it does not work.

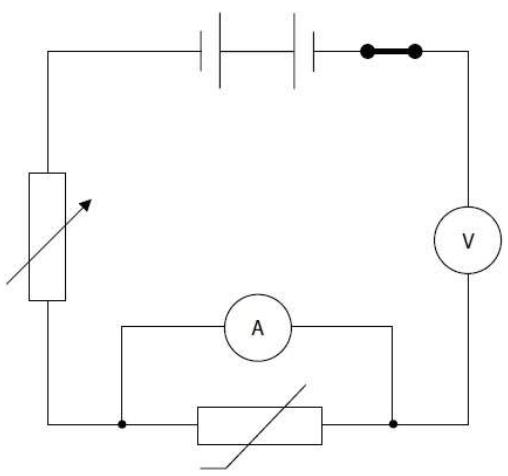


Figure 5

Give **three** modifications the student should make to the circuit so that the circuit works correctly.

(b) The student uses the equipment shown in Figure 6 to measure the temperature of the thermistor.

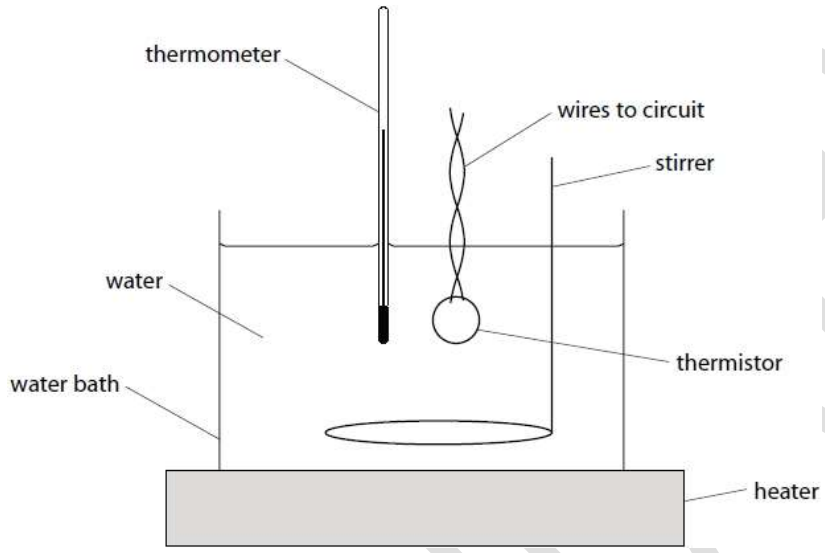


Figure 6

(i) Give **one** reason for using the water bath.

(1)

(ii) The equipment shown in Figure 6 is for investigations in the temperature range from 20°C to 100°C.
State **one** way the student could develop this experimental procedure to investigate temperatures outside this range.

(1)

(c) The student takes measurements for two other components, **A** and **B**.
The results for both these components are shown in Figure 7.

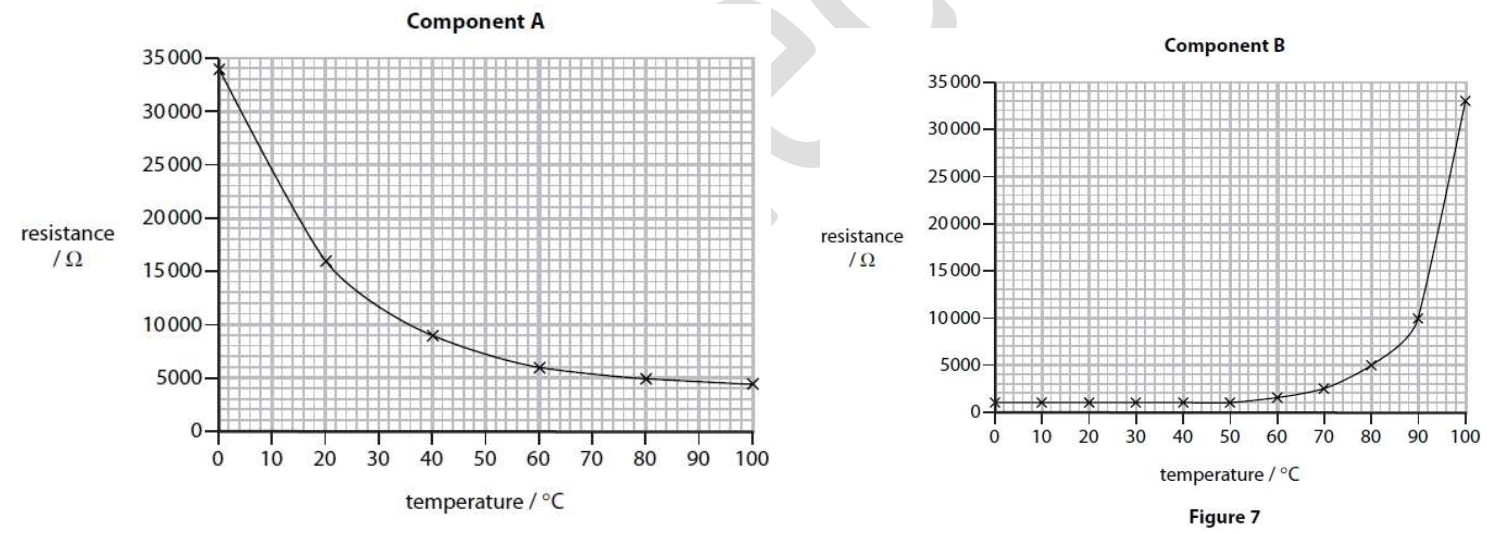


Figure 7

(i) Compare and contrast how the resistances of component **A** and component **B** vary with temperature.

(3)

(ii) Component **A** is connected to a 12 V supply.
Which of these is the current in component **A** when the temperature is 80°C?

(1)

☐ **A** $I = 12 \times 5000$

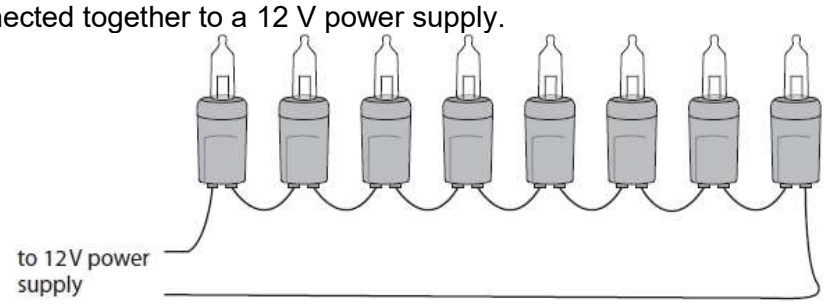
☐ **B** $I = \frac{12}{5000}$

☐ **C** $I = \frac{12^2}{5000}$

☐ **D** $I = \sqrt{\left(\frac{12}{5000}\right)}$

Q26.

Figure 18 shows identical filament lamps connected together to a 12 V power supply.



(i) Calculate the potential difference across each lamp.

(1)

(ii) The power output of each lamp is 0.75 W
Calculate the resistance of each lamp.

(4)

Q27.

A technician investigates different electrical devices that are used in a car.
The technician connects a device to the 12 V car battery.
The technician measures the current in the circuit and the potential difference (voltage) across the device.
Figure 8 shows the car battery and the device that is being tested.

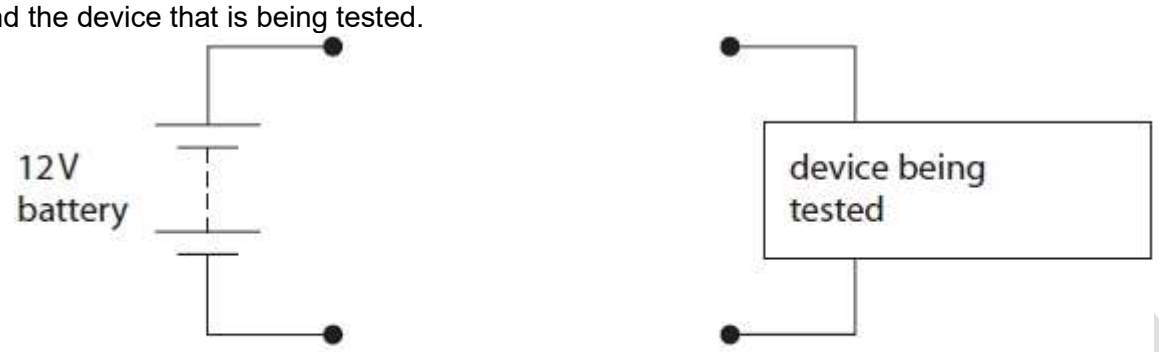


Figure 8

(i) Draw on Figure 8 to show how the circuit should be completed so that the current in the circuit and voltage across the device can be measured.

(2)

(ii) The technician tests a headlamp.
The current in the headlamp is 4.8 A when connected to the 12 V battery.
Calculate the power supplied to the headlamp.

(2)

(iii) The technician tests an interior light.
The current in the interior light is 600 mA when connected to the 12 V battery.
Calculate the energy transferred to the interior light in 7 minutes.
Use an equation selected from the list of equations at the end of the paper.

(2)

Q28.

Figure 1 shows a lamp connected to a d.c. power supply.

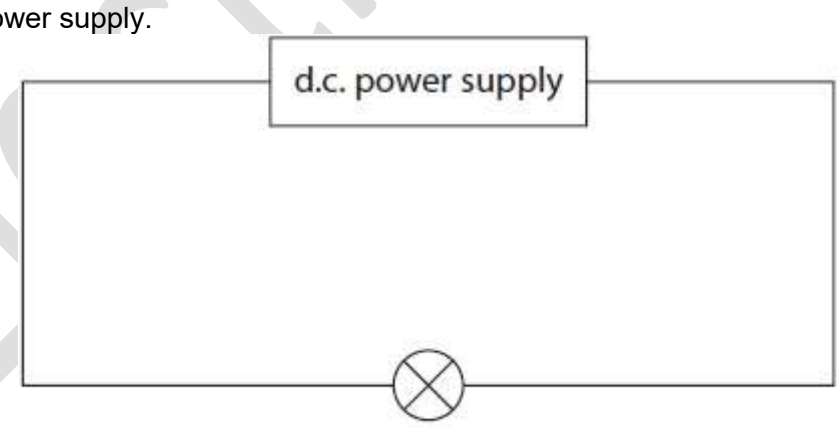


Figure 1

The power supply provides a potential difference (voltage) of 4.5 V.
The current in the lamp is 0.30 A.
Another **identical** lamp is added to the circuit, as shown in Figure 2.

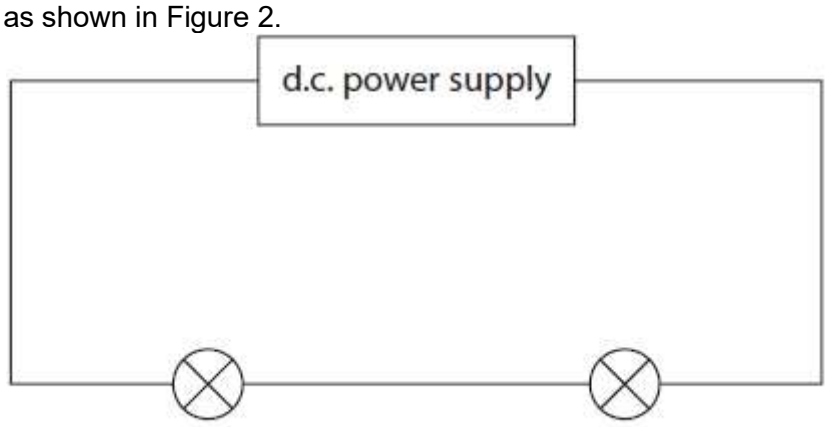


Figure 2

The power supply provides the same potential difference as it provided in the circuit in Figure 1.
State and explain the difference between the brightness of the lamp in Figure 1 and the brightness of a lamp in Figure 2.

(3)

Q29.

A car headlamp has a power rating of 55 W when the current in the headlamp is 4.4 A.
(i) State the equation relating power, current and resistance.

(1)

(ii) Calculate the resistance of the headlamp.

(3)

Q30.

Figure 16 shows a cardboard tube with a wire coming out from each end.

Figure 16

There are two 10 ohm resistors inside the cardboard tube.
A potential difference of 6.0 V is connected between P and Q.
There is a current of 1.2 A in the wires.
Deduce how the resistors have been arranged inside the cardboard tube.

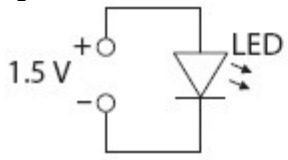
(3)

Q31.

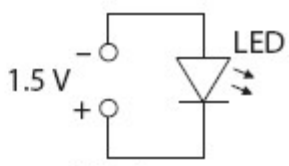
(a) What is the name of the device used to change the size of an alternating voltage?

(1)

(b) A light emitting diode (LED) can only emit light when connected correctly to a potential difference.

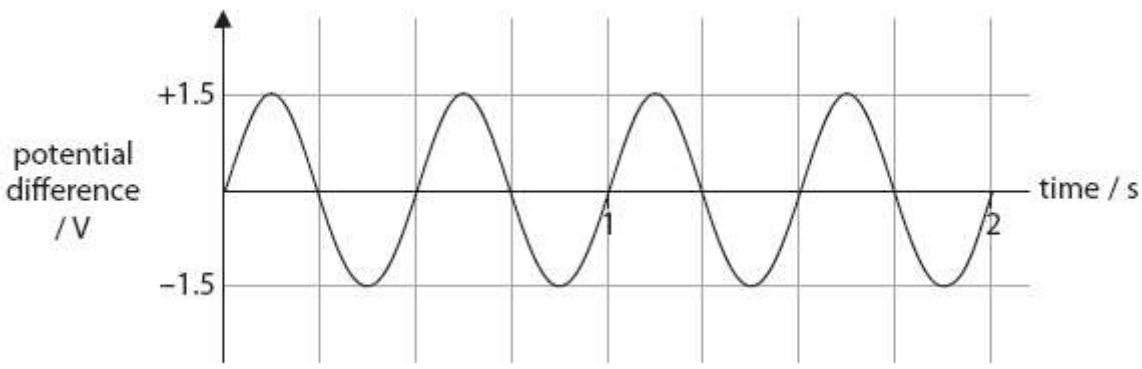


LED emits light



LED does **not** emit light

Use this information to suggest what happens when this alternating voltage is connected across the LED.



(c) A LED lamp has a power rating of 3 W.
The voltage across the lamp is 12 V.
Calculate the current in the lamp.

(3)

*(d) Some research has been carried out into replacing fluorescent lamp fittings with LED fittings.

photo of stairwell with fluorescent fitting

photo of stairwell with LED fitting

The data in the table is taken from the report of a trial using LEDs to light stairwells and corridors in a large building.

total energy saved each year by using LEDs	3 000 kW h
LED fitting cost	£2 000
CO_2 saving each year by using LEDs	1.6 tonnes
change in lighting levels by using LEDs	200%
average price of electrical energy	14 p / kW h
average lifetime of LED fittings	50 000 hours
average lifetime of fluorescent fittings	10 000 hours

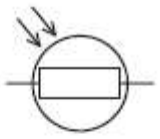
Use the information to discuss the benefits of replacing fluorescent fittings with LED fittings.

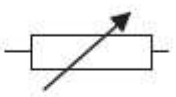
(6)

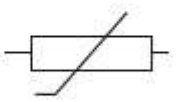
Q32.

Which of these shows the correct circuit symbol for a thermistor?

(1)

☒ **A** 

☒ **B** 

☒ **C** 

☒ **D** 

Q33.

The photograph shows the security check-in at an airport.

An X-ray machine is used to scan luggage for dangerous items.
A metal detector is used to check people for dangerous items.

(a) (i) Suggest why people are not scanned with X-rays in an airport but have X-rays in a hospital.

(2)

(ii) The security people work near the X-ray machine.
Explain how they are protected from the X-rays.

(2)

(b) X-rays are produced when fast moving electrons collide with a metal anode in a vacuum tube.

(i) The electrons come from the cathode by the process of thermionic emission.
Explain what is meant by thermionic emission.

(2)

(ii) The current in the vacuum tube is 7.0 mA.
charge on an electron is 1.6×10^{-19} C.
Complete the sentence by putting a cross (☒) in the box next to your answer.
The number of electrons colliding with the metal anode in one second is

(1)

☒ **A** 2.3×10^{-20}
☒ **B** 2.3×10^{-17}
☒ **C** 4.4×10^{16}
☒ **D** 4.4×10^{19}

(iii) In order to produce X-rays which can penetrate the luggage, each electron must have at least an energy of 1.4×10^{-14} J.
The charge on an electron is 1.6×10^{-19} C.
Calculate the accelerating potential difference which will produce electrons of this energy.

(3)