# Electrical Quantities and Components

**Q1.**

The resistivity of a metal is an important property of wire used in an electric circuit.

Nichrome wire is often used in heating elements. Nichrome wire is used to make a coil for a 65 W mains powered heater. The nichrome wire has a resistance per metre of 87.5 $\Omega$ m$^{-1}$.

Calculate the length of wire required.

potential difference across the coil = 230 V

(3)

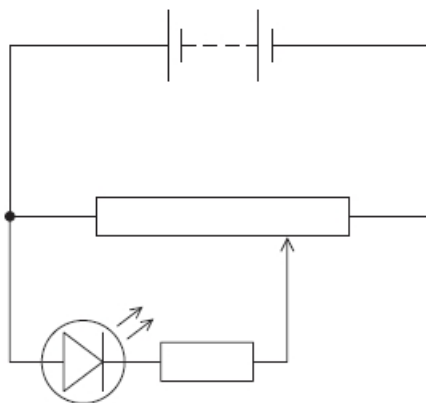...........................................................................................................................................

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Length of wire required = ...........................................................
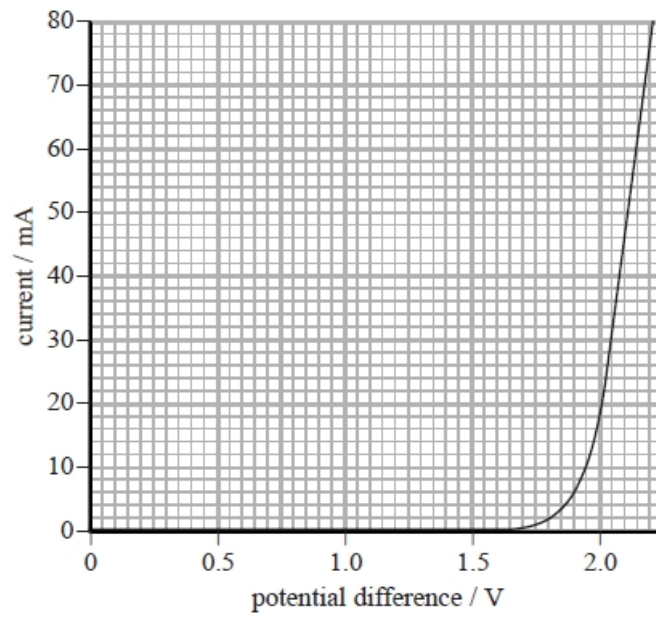
**(Total for question = 3 marks)**

**Q2.**

A student wanted to plot a graph of current against potential difference for a light emitting diode (LED). He used the circuit shown.

The graph of current against potential difference obtained by the student is shown.



(i) The student wrote the following conclusion.

"The graph shows that in general the LED is not an ohmic conductor. However, for potential differences greater than +2 V, Ohm's law is obeyed since the graph is linear in this region."
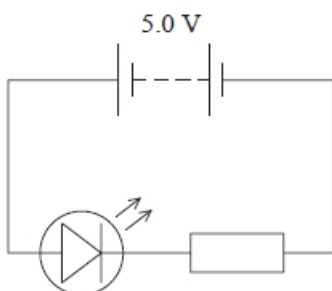
Criticise the student's conclusion.

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(ii) The student used the LED with a 5.0 V power supply as shown in the circuit.

5.0 V

To be lit to normal brightness the current through the LED must be 18 mA.
Calculate the resistance of the resistor needed in the circuit.

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Resistance = ..........................................................

**(Total for question = 6 marks)**

**Q3.**

Analogue ammeters were used before digital meters became widely available.

The analogue ammeter shown will measure a maximum current of 1.0 mA and has a resistance of 18 Ω.

0    0.2  0.4 0.6  0.8    1
D C
MILLIAMPERES
CLASS-2.5                    MU-45

(Source: © David J. Green/Alamy Stock Photo)

The analogue ammeter can be adapted to measure a larger current by adding a resistor, known as a shunt, in parallel with the ammeter. The arrangement is shown below.

The analogue ammeter is represented by the 18 Ω resistor.
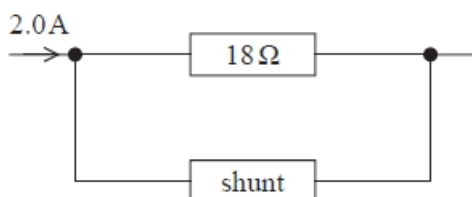


The maximum current through the 18 Ω resistor remains as 1.0 mA.

Show that the shunt would need to have a resistance of about 0.01 Ω to adapt this ammeter to read up to a maximum current of 2.0 A.
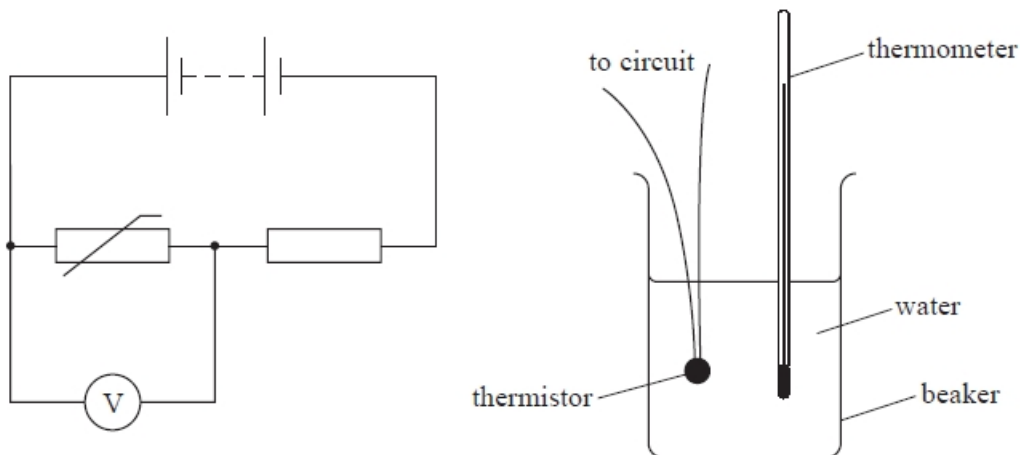
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**(Total for question = 3 marks)**

**Q4.**

A student carried out an experiment to calibrate a thermistor. She connected the thermistor in series with a resistor and a power supply as shown. Then she placed the thermistor in a beaker of hot water and used a thermometer to record the temperature $\theta$ of the water.



The student recorded $\theta$ and corresponding values of the reading $V$ on the voltmeter as the water cooled.

Explain, making reference to charge carriers, why $V$ increased as the water cooled.

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**(Total for question = 3 marks)**

**Q5.**

A student investigates how the efficiency of an electric motor being used to raise a load varies with the weight of the load.

The time taken for the motor to lift a load from the floor to the maximum height was measured using a stopwatch. The load was varied by adding weights, each marked '1.00 N'.

The spreadsheet shows the student's results (columns A to E) and calculation (column F).

| | A | B | C | D | E | F |
|---|---|---|---|---|---|---|
| | load /N | current / A | potential difference / V | time / s | change in height / m | efficiency |
| 1 | | | | | | |
| 2 | 2.00 | 1.8 | 4.6 | 1.52 | 0.825 | 0.13 |
| 3 | 3.00 | 1.9 | 4.4 | 2.05 | 0.825 | 0.14 |
| 4 | 4.00 | 2.1 | 4.3 | 2.19 | 0.825 | 0.17 |
| 5 | 5.00 | 2.3 | 5.1 | 2.26 | 0.825 | 0.16 |
| 6 | 6.00 | 2.5 | 4.5 | 2.48 | 0.825 | 0.18 |
| 7 | 7.00 | 3.1 | 5.2 | 2.17 | 0.825 | 0.17 |
| 8 | 8.00 | 3.7 | 4.8 | 2.68 | 0.825 | 0.14 |
| 9 | 9.00 | 3.9 | 4.8 | 3.36 | 0.825 | 0.12 |
| 10 | 10.00 | 4.2 | 4.7 | 3.72 | 0.825 | 0.11 |

Explain how the value in cell F4 has been determined using the results obtained.

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**(Total for question = 3 marks)**

**Q6.**

A student set up the circuit shown and measured the current *I* through the filament lamp for a range of values of potential difference (p.d.) *V*.
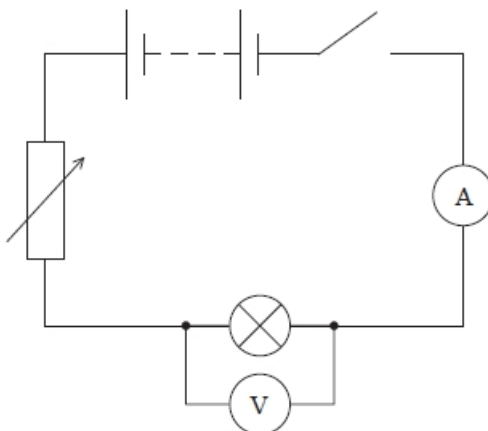


The student's data is shown in the table.

| V / V | I / A |
|-------|-------|
| 3.0 | 0.6 |
| 4.0 | 0.75 |
| 6.0 | 1.00 |
| 8.0 | 1.20 |
| 10.0 | 1.35 |
| 12.0 | 1.5 |

The student drew a graph of how current varies with p.d. She drew a straight line on the graph and claimed that the data demonstrates that the filament lamp obeys Ohm's law because the graph is linear.
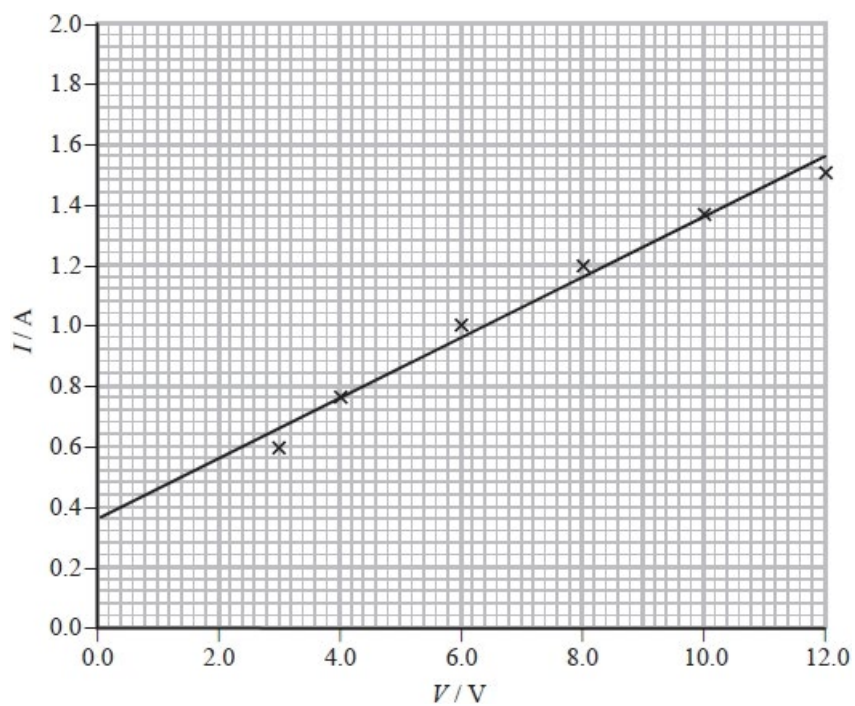
Assess the validity of the student's statement.

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**(Total for question = 4 marks)**

**Q7.**

The resistivity of a metal is an important property of wire used in an electric circuit.

A student carried out an experiment to determine the resistivity of a type of wire.
He used a micrometer to measure the diameter $d$ of the wire.

(Source: © Viktor Chursin/Shutterstock)

He recorded the following values.

| $d_1$ / mm | $d_2$ / mm | $d_3$ / mm | $d_4$ / mm |
|------------|------------|------------|------------|
| 1.40 | 1.44 | 1.42 | 1.41 |

(i)  Calculate the percentage uncertainty in the mean diameter of the wire.

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% uncertainty in mean diameter of wire = ...........................................................

(ii)  The student used an ohmmeter to measure the resistance $R$ of a 1.65 m length of the wire.

He looked up the resistivity values of some materials.

| Material | Titanium | Constantan | Stainless Steel |
|----------|----------|------------|-----------------|
| Resistivity / $10^{-7}\,\Omega\,m$ | 4.2 | 4.7 | 6.9 |

Identify the material of the wire.
$R = 0.72\ \Omega$

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**(Total for question = 6 marks)**

**Q8.**

The photographs show two types of caliper being used, in turn, to measure the diameter of an iron rod.

Caliper 1



diameter = 12.17 mm

Caliper 2



diameter = 12.2 mm

The value obtained from caliper 2 was used to determine the cross-sectional area of the rod and the electrical properties of the rod were investigated.

Calculate the drift velocity for the charge carriers in the rod when the current in the rod is 1.9 A.

diameter of rod = 12.2 mm
charge carrier density for iron = $1.7 \times 10^{29}$ m$^{-3}$

(3)

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Drift velocity = ...........................................................

**(Total for question = 3 marks)**

**Q9.**

A student carried out an experiment to determine the resistivity of nichrome wire.

He used an ohmmeter to measure the resistance of a length of nichrome wire as shown.
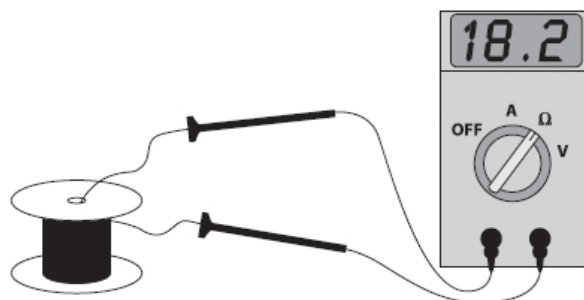


The diameter of the wire was measured as 0.27 mm ± 0.01 mm.
The length of the wire was measured as 1.25 m ± 0.05 m.

Calculate the minimum value of resistivity possible from the student's data.

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Minimum resistivity = ...........................................................

**(Total for question = 4 marks)**

**Q10.**

The world solar challenge is set every two years, in Australia. The challenge is to complete a three thousand kilometre route with a vehicle powered only by the Sun.

Vehicles have their surfaces fitted with solar panels, as shown in the photograph.
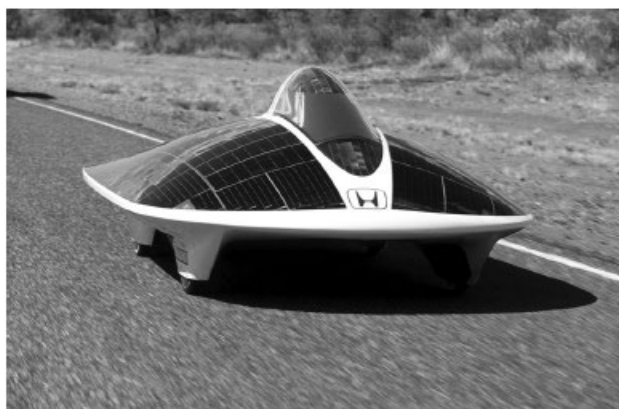


(Source: © LAURENT DOUEK/LOOK AT SCIENCES/SCIENCE PHOTO LIBRARY)

A bank of 380 of these solar panels is used to charge the battery in a vehicle.

The panels are connected in parallel and the current provided by each panel is 0.45 A.

When fully charged, the energy stored in the battery is 12 kW h.

The potential difference from each cell is 5.5V.

Calculate the time, in hours, to fully charge this battery if the solar panels are in sunlight. Assume the efficiency of charging this battery is 100%.

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Time = ......................................................... hours

**(Total for question = 3 marks)**

**Q11.**

An electric motor takes 45.0 s to lift a mass of 800 kg through a vertical height of 14.0 m.
The potential difference across the motor is 230 V and the current is 13.0 A.

Calculate the efficiency of the motor.

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Efficiency = .........................................................

**(Total for question = 3 marks)**

**Q12.**

A thermistor can be used to control a heater. When the temperature falls below a certain
value the heater is switched on. The thermistor is connected in series with a fixed resistor R
in a potential divider circuit as shown.

The heater circuit is connected across R and will switch on when the potential difference across it is above 5.5 V.

The variation of resistance of the thermistor $R_T$ with temperature is shown on the graph.



(Source: http://reviseomatic.org/help/e-resistors/ThermistorLogGraph.gif)
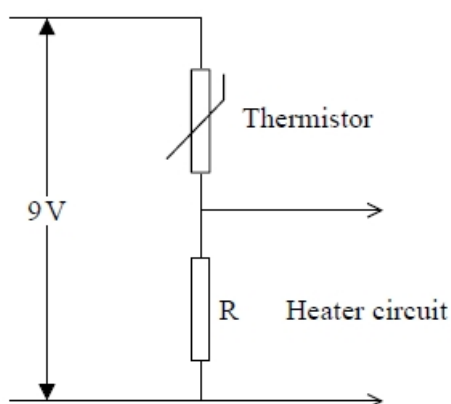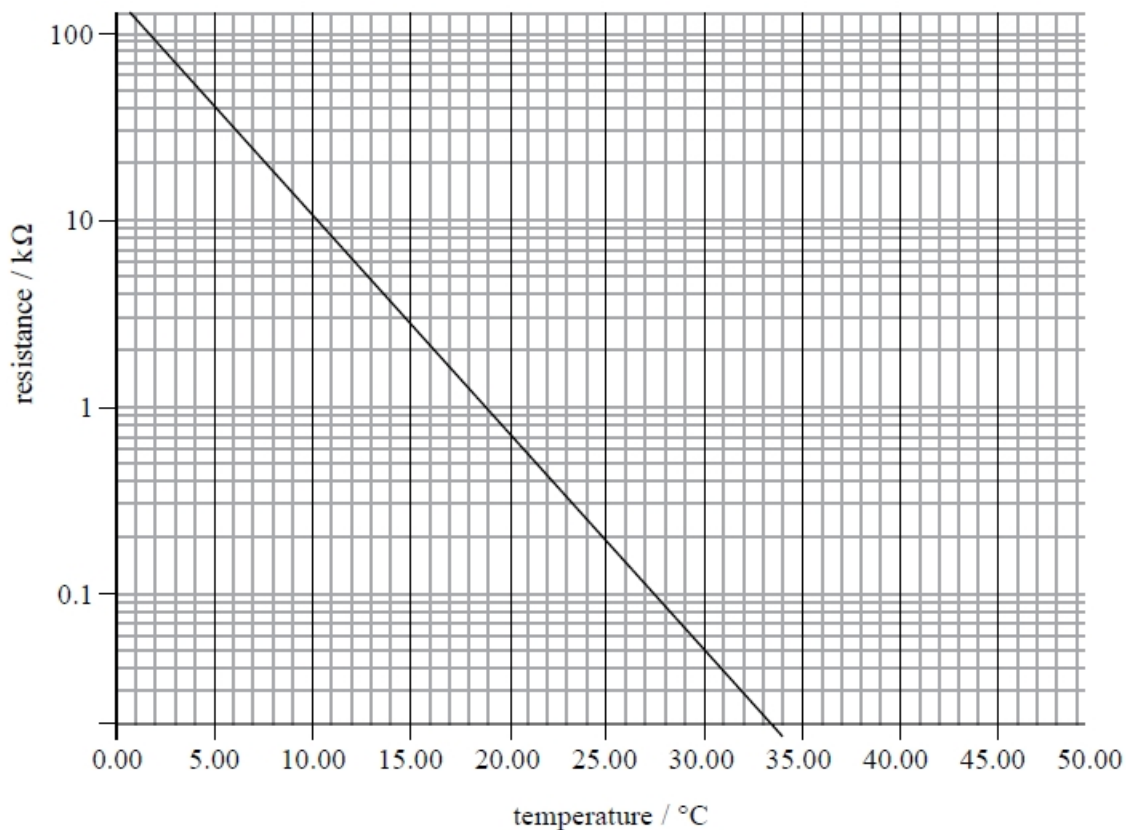
The heater switches on when the temperature falls below 20 °C.

Calculate the resistance of the fixed resistor R.

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Resistance= ...........................................................

**(Total for question = 3 marks)**

**Q13.**

Pencil lead is a mixture of graphite and clay. The proportions of graphite and clay in the sample determine the hardness of the pencil lead, as well as the resistivity.

(a) The diagram shows two samples of pencil lead made from the same mixture of graphite and clay.
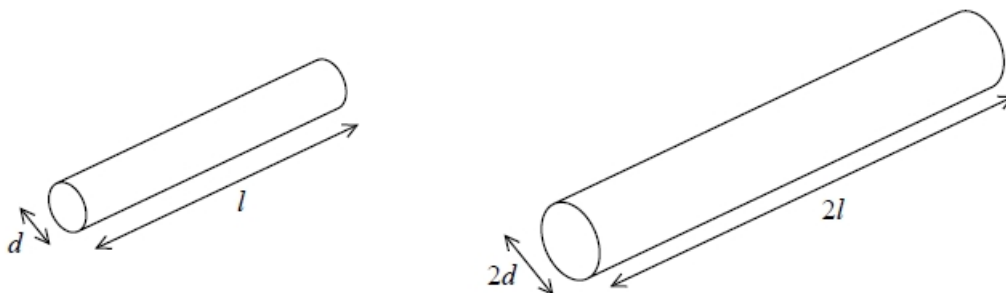


Sample A has a resistance $R_A$. Sample B has a resistance $R_B$ and is twice the length and twice the diameter of sample A.
Calculate the ratio $R_B/R_A$.

(2)

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$R_B/R_A$ = ..............................................................

(b)  A graph supplied by the manufacturer shows that the resistance $R$ of a pencil lead is inversely proportional to its cross-sectional area $A$.
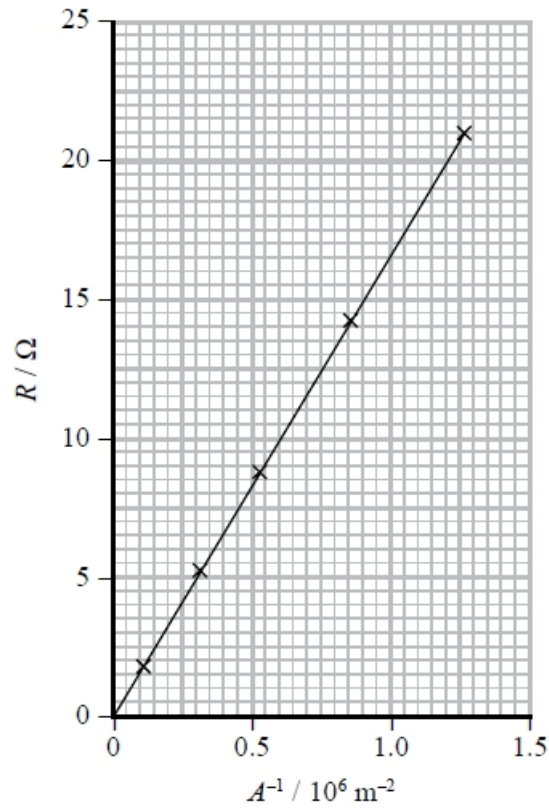


The resistivity of graphite is $3 \times 10^{-5}$ Ω m. Use the graph to draw a conclusion about the effect of adding clay to graphite.
Length of pencil lead = 15.0 cm.

(4)

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**(Total for question = 6 marks)**

**Q14.**

Archaeologists use resistivity surveying of soil to search for the remains of buildings and settlements under the ground.

A basic arrangement that can be used to determine the resistivity of a region of soil is shown.
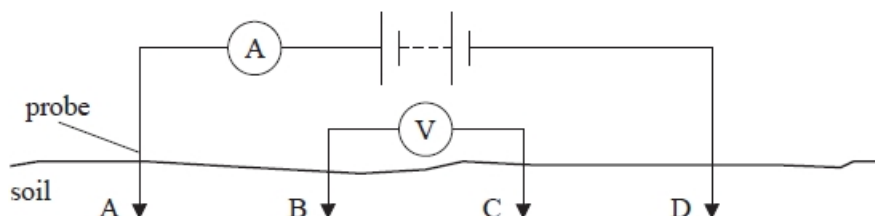


Probes are placed at positions A and D so that the length AD of soil forms part of the circuit. The ammeter measures the current through the soil.

A second pair of probes connected to a voltmeter is placed at positions B and C.
This measures the potential difference between positions B and C in the soil.

Explain how the reading on the voltmeter will change if the length BC increases.

(2)

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**(Total for question = 2 marks)**

**Q15.**

A hair dryer is used for 3 minutes. The operating current is 6 A.

What charge flows in this time?

(1)

☒ **A**   0.03 C

☒ **B**   2 C

☒ **C**   18 C

☒ **D**   1080 C

**(Total for question = 1 mark)**

**Q16.**

The graph shows how the potential difference *V* varies with the current *I* for a circuit component.
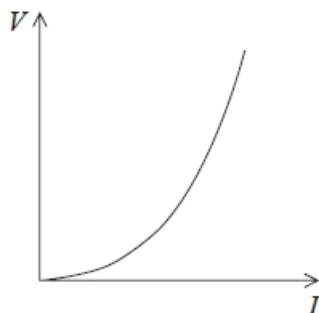


Which of the following could be the circuit component?

- ☒ **A** diode
- ☒ **B** filament bulb
- ☒ **C** ohmic resistor
- ☒ **D** thermistor

**(Total for question = 1 mark)**

**Q17.**

A light dependent resistor and a negative temperature coefficient thermistor are connected in series.

Which of the following combinations of illumination and temperature will result in the highest combined resistance?

(1)

- ☒ **A** dark and cold

- ☒ **B** dark and hot

- ☒ **C** light and cold

- ☒ **D** light and hot

**(Total for question = 1 mark)**

**Q18.**

A potential divider circuit may contain a component known as a potentiometer. One type of potentiometer consists of a track with terminals X and Y at either end. There is a sliding contact that can move along the track connected to a terminal Z as shown.
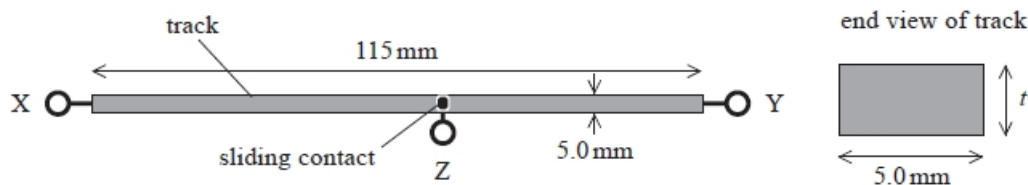


The length of the track is 115 mm and the width is 5.0 mm.

The resistance of the track between terminal X and terminal Y is 12.0 kΩ.

Calculate the thickness $t$ of the track.

Resistivity of track material = 0.49 Ω m

(3)

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$t$ = ...........................................................

**(Total for question = 3 marks)**

**Q19.**

A student investigated the effect of temperature on the resistance of a thermistor, using the circuit shown.
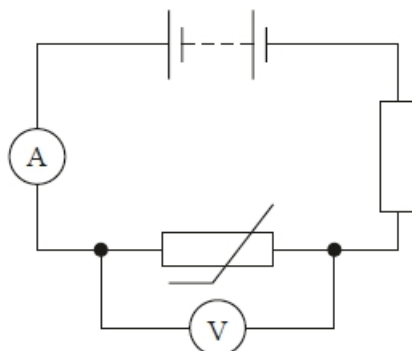


A negative temperature coefficient thermistor was used in this circuit.

With reference to the charge carriers in the thermistor, explain what happens to the p.d. across the thermistor as the temperature increases.

(3)

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**(Total for question = 3 marks)**

**Q20.**

The diagram shows a graph of current *I* against potential difference *V* for an electrical component.
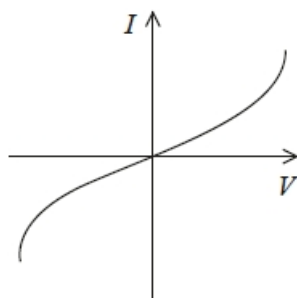


Which of the following components would produce a graph of this shape?

☒ **A**   filament bulb

☒ **B**   metallic conductor

☒ **C**   negative temperature coefficient thermistor

☒ **D**   ohmic conductor

**(Total for question = 1 mark)**

**Q21.**

A cell is connected across a resistor. After a while the internal resistance of the cell increases.

Which row of the table correctly shows the change in the current in the circuit and the change in the terminal potential difference across the cell?

| | | Current | Terminal potential difference |
|---|---|---|---|
| ☒ | **A** | decreases | decreases |
| ☒ | **B** | decreases | increases |
| ☒ | **C** | increases | decreases |
| ☒ | **D** | increases | increases |

**(Total for question = 1 mark)**

**Q22.**

The current-potential difference graphs for a resistor and a thermistor are shown.
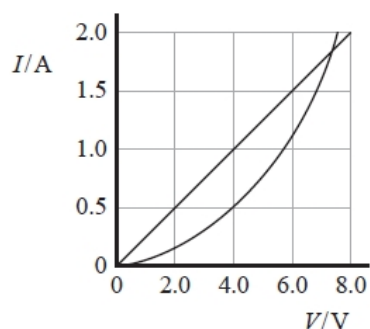


The resistor and thermistor are connected in series to a 6 V battery.

What is the current, in amps, in the resistor?

(1)

☒ **A**   0.5
☐ **B**   1.0
☐ **C**   1.5
☐ **D**   2.0

**(Total for question = 1 mark)**

**Q23.**

Which of the following graphs shows how the current *I* through a thermistor varies with the potential difference *V* across the thermistor?



☐ **A**

☒ **B**

☐ **C**

☒ **D**
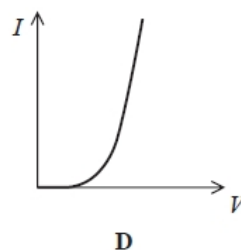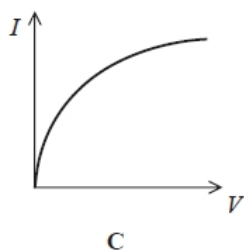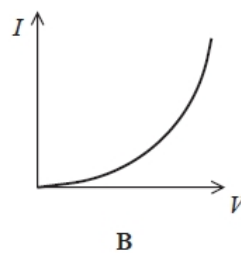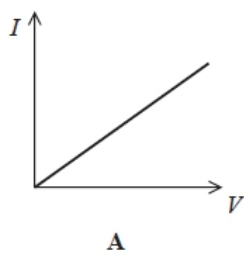
**(Total for question = 1 mark)**

**Q24.**

Conducting putty is a material that is a relatively good conductor and can be easily moulded into different shapes.

A student decides to investigate how the resistance $R$ of a cylinder of conducting putty depends upon the cross-sectional area $A$ of the cylinder.

(a) She sets up the circuit shown and keeps the length $l$ of the cylinder constant at 7.5 cm. She uses the ammeter and voltmeter readings to determine the resistance of cylinders of different cross-sectional areas.
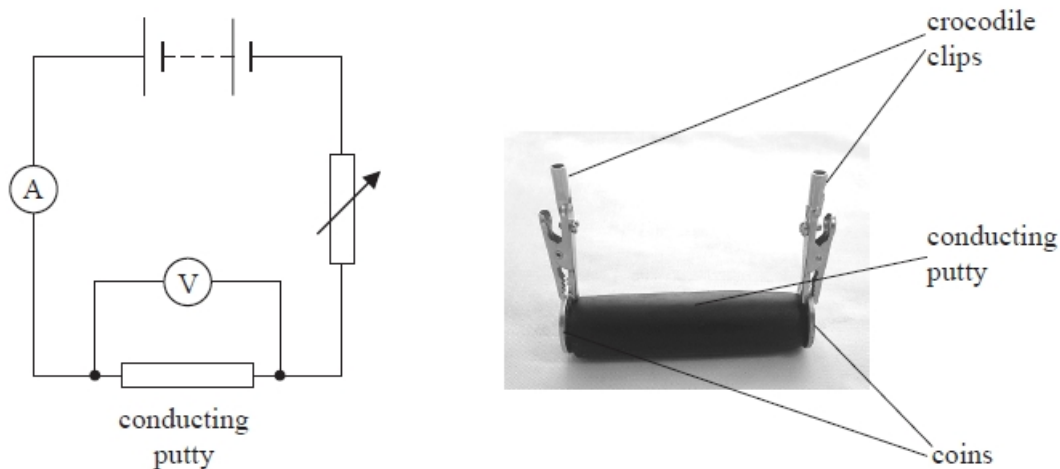


The student's results are shown in the table.

| Diameter / cm | Resistance / $\Omega$ | $(l\,/\,A)\,/\,m^{-1}$ |
|---|---|---|
| 0.4 | 56.0 | 1490 |
| 1.0 | 37.5 | 968 |
| 1.5 | 16.7 | 430 |
| 2.0 | 9.44 | 242 |
| 2.5 | 6.00 | 155 |

(i) Plot a graph of *R* against *l/A*.

**(4)**
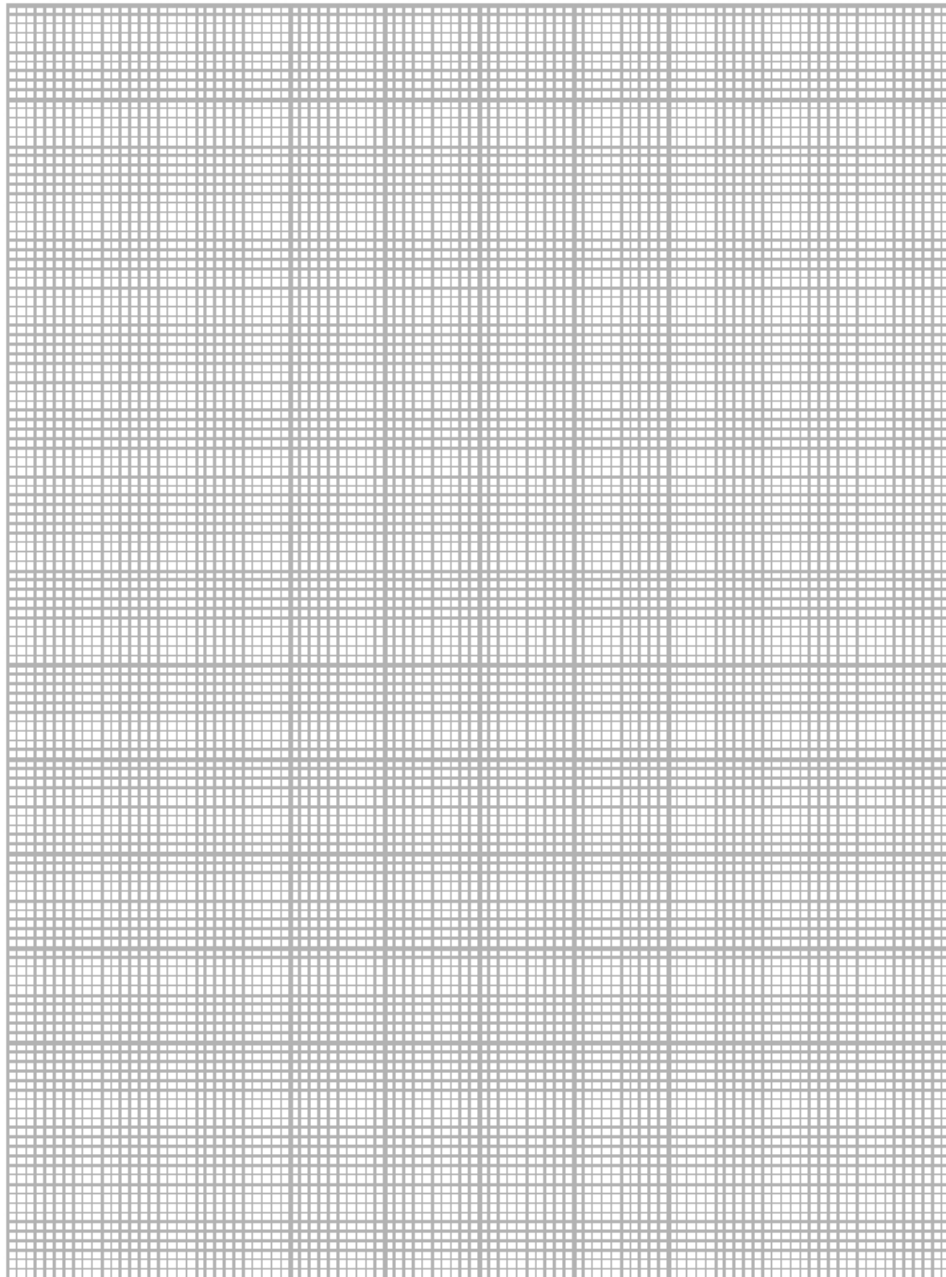
(ii) Use your graph to determine a value for the resistivity of the putty.

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Resistivity = ..........................................................

(b)  The photographs show how the student obtained measurements for the length and diameter of a cylinder.
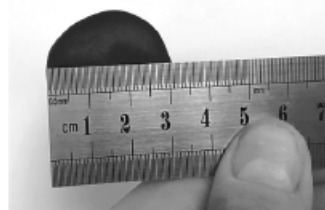


The student records the following readings:

length = 90 mm; diameter = 31 mm

Identify two problems with this method of determining the dimensions of the cylinder and for each problem identify a solution.

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**(Total for question = 10 marks)**

**Q25.**

A volt can be defined as a

(1)

☒ **A**    coulomb per joule.

☒ **B**    coulomb per second.

☒ **C**    joule per coulomb.

☒ **D**    joule per second.

**(Total for question = 1 mark)**

**Q26.**

Resistivity can be described correctly as

☒ **A**   resistance of a unit length.

☒ **B**   resistance per unit area.

☒ **C**   resistance per unit volume.

☒ **D**   resistance of a unit cube.

**(Total for question = 1 mark)**

**Q27.**

A potential difference is applied across the metal filament of a light bulb and charge flows.

By referring to the mean drift velocity of the electrons, explain what happens to the current in the metal filament if the potential difference is unchanged and the temperature of the metal increases.

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**(Total for question = 3 marks)**

**Q28.**

The intensity of light incident on a light dependent resistor (LDR) can vary both its electrical resistance $R$ and the number of charge carriers per unit volume $n$. The light intensity on an LDR is increased.

Which row of the table describes the effect on $R$ and $n$?

|  |  | R | n |
|---|---|---|---|
| ☒ | A | decreases | decreases |
| ☒ | B | decreases | increases |
| ☒ | C | increases | decreases |
| ☒ | D | increases | increases |

**(Total for question = 1 mark)**

**Q29.**

Resistance can also be affected by temperature.

Explain why the resistance of a metal sample increases with an increase of temperature.

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**(Total for question = 3 marks)**

**Q30.**

A thermistor can be used to control a heater. When the temperature falls below a certain value the heater is switched on. The thermistor is connected in series with a fixed resistor R in a potential divider circuit as shown.



The heater circuit is connected across R and will switch on when the potential difference across it is above 5.5 V.

The variation of resistance of the thermistor $R_T$ with temperature is shown on the graph.



(Source: http://reviseomatic.org/help/e-resistors/ThermistorLogGraph.gif)
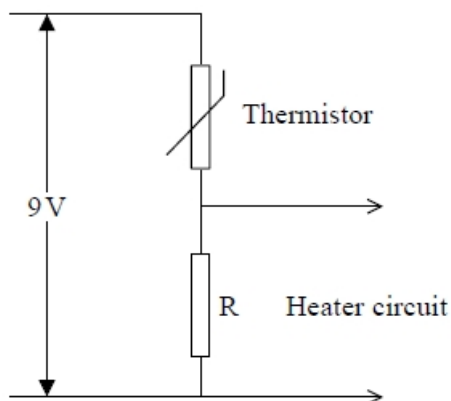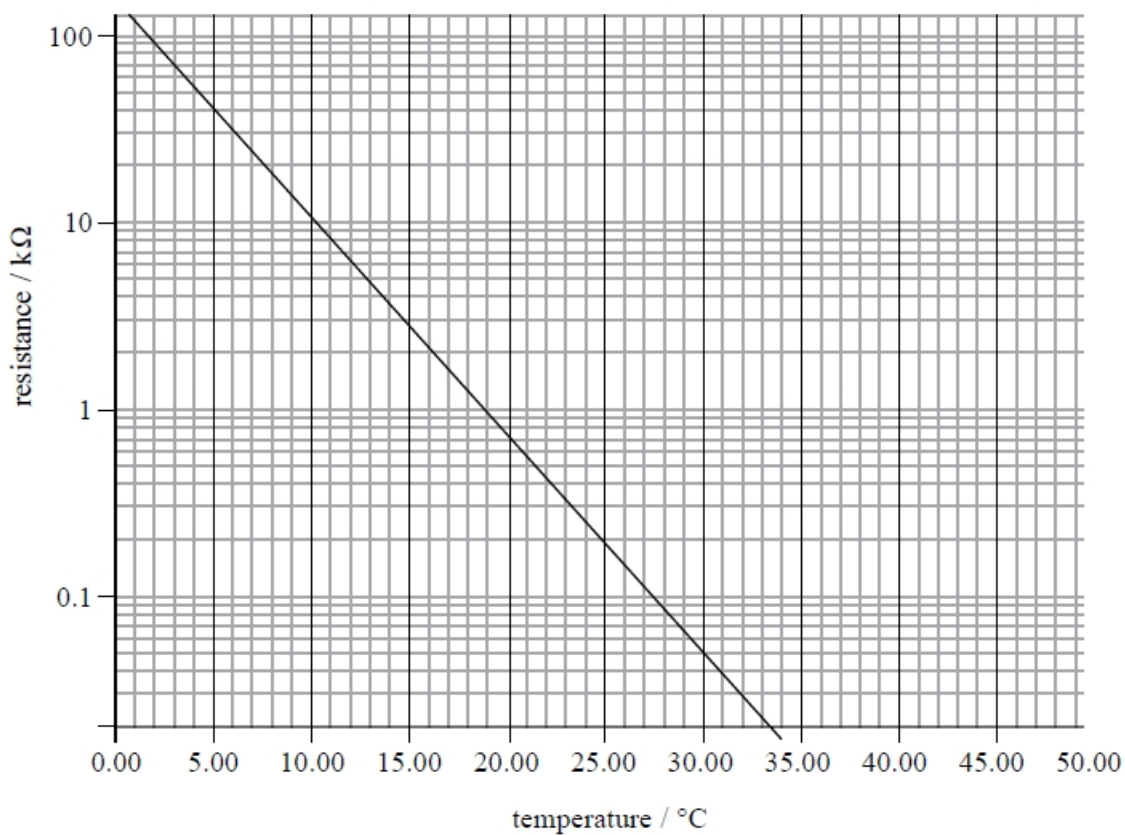
With reference to charge carriers, explain why the resistance of the thermistor $R_T$, changes with temperature.

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**(Total for question = 2 marks)**

**Q31.**

A motor lifts a block of mass 0.050kg at a constant velocity of 0.40 m s$^{-1}$.

The current in the motor is 85mA and the potential difference across it is 3.0V.
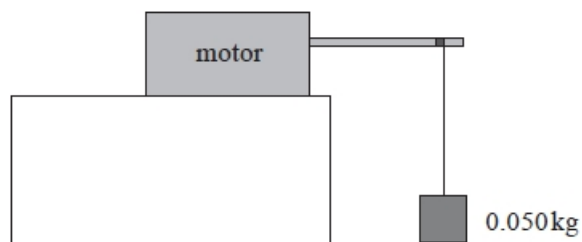


Calculate the efficiency of the motor.

(3)

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Efficiency of the motor = ...........................................................

**(Total for question = 3 marks)**

**Q32.**

A mobile phone is powered by a lithium-ion battery. The information shown is taken from the battery.

3.82 V

6.91 W h

The mobile phone, when purchased, was supplied with a charging plug marked 1 A, 5V. The mobile phone owner lost the original charging plug and replaced it with a charging plug marked 0.5 A, 5 V.

original charging plug
1A, 5 V

replacement charging plug
0.5A, 5 V

By evaluating the information given, discuss the suitability of using the replacement charging plug for this mobile phone. Include references to possible benefits, disadvantages and risks associated with using the replacement charging plug.

(4)

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**(Total for question = 4 marks)**

**Q33.**

A constant current maintained in a copper wire causes the temperature of the wire to increase.

Which of the following does **not** increase?

☒ **A**   amplitude of vibration of the lattice ions

☒ **B**   number of conduction electrons per unit volume

☒ **C**   rate of collision of conduction electrons with lattice ions

☒ **D**   rate of energy transfer from conduction electrons to lattice ions

**(Total for question = 1 mark)**

**Q34.**

Analogue ammeters were used before digital meters became widely available.

The analogue ammeter shown will measure a maximum current of 1.0 mA and has a resistance of 18 Ω.



(Source: © David J. Green/Alamy Stock Photo)

The analogue ammeter can be adapted to measure a larger current by adding a resistor, known as a shunt, in parallel with the ammeter.

The arrangement is shown below. The analogue ammeter is represented by the 18 Ω resistor.
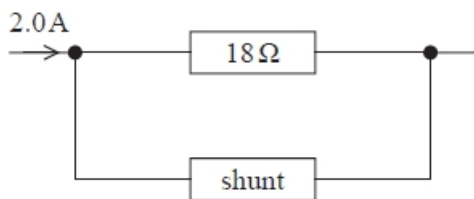


The maximum current through the 18 Ω resistor remains as 1.0 mA.

A shunt of this resistance was usually made from Manganin wire.

Calculate the length of Manganin wire of radius 0.95 mm required to make this shunt.

resistivity of Manganin = $4.55 \times 10^{-7}$ Ω m

(3)

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Length = ...........................................................

**(Total for question = 3 marks)**

**Q35.**

A light dependent resistor is connected across a cell of negligible internal resistance. The light intensity is increased.

Which of the following statements about the current is correct?

☒ **A**   It decreases because there is an increase in the number of conduction electrons.

☒ **B**   It increases because there is an increase in the number of conduction electrons.

☒ **C**   It decreases because the amplitude of lattice vibrations decreases.

☒ **D**   It increases because the amplitude of lattice vibrations increases.

**(Total for question = 1 mark)**

**Q36.**

A light dependent resistor (LDR) and a resistor are connected to a battery, as shown.
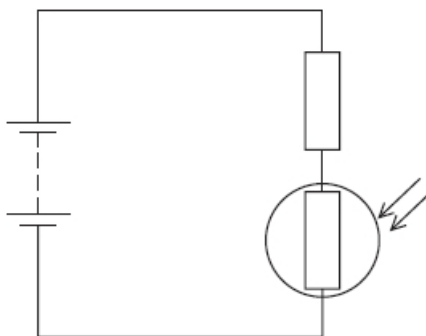


The intensity of light incident on the LDR increases.

Which row of the table describes the change in the resistance of the LDR and the change in the potential difference across the resistor?

|  |  | Resistance of LDR | Potential difference across the resistor |
|---|---|---|---|
| ☒ | A | decreases | decreases |
| ☒ | B | decreases | increases |
| ☒ | C | increases | decreases |
| ☒ | D | increases | increases |

**(Total for question = 1 mark)**

**Q37.**

A solar panel uses electromagnetic radiation from the Sun to generate electricity.

In one installation a sensor in the solar panel measures the intensity of radiation arriving from different directions. A motor rotates the solar panel so that it always faces the brightest part of the sky.

The circuit diagram shows how a light dependent resistor (LDR) can be used to produce an output potential difference (p.d.) that is dependent on the intensity of light. This output p.d. is connected to a motor circuit that operates the movement of the solar panel.
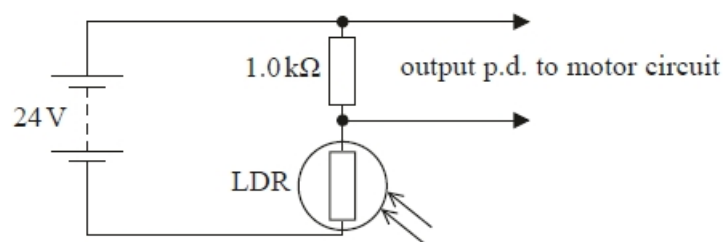
Initially the motor is switched off. The light intensity increases and the resistance of the LDR decreases to 750 Ω.

The motor switches on when the output p.d. is above 13 V.

Deduce whether this change in light intensity causes the motor to switch on.

(3)

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**(Total for question = 3 marks)**

**Q38.**

The photograph shows a statue of Buddha in Sri Lanka, which is protected by a lightning conductor.



© Valery Shanin/123RF

During a storm, a potential difference of 2.7 MV was generated between a cloud and the top of the lightning conductor on the statue. A flash of lightning passed between the cloud and the lightning conductor, producing a current of 25 kA for a time of 7.5 ms.

Calculate the energy transferred by the lightning strike.

(3)

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Energy transferred = ..........................................................

**(Total for question = 3 marks)**

**Q39.**

A series circuit consists of two resistors with resistances $R_1$ and $R_2$ and a battery of potential difference $V$.

Which of the following gives the potential difference across the resistor with resistance $R_2$?

☐ **A** $\dfrac{R_1}{R_2} V$

(1)

☐ **B** $\dfrac{R_2}{R_1} V$

**(Total for question = 1 mark)**

☐ **C** $\dfrac{R_1}{R_1 + R_2} V$

☐ **D** $\dfrac{R_2}{R_1 + R_2} V$

**Q40.**

Filament and fluorescent are two types of light bulb.

Filament light bulbs contain a tightly coiled wire filament, surrounded by an inert gas and encased in a thin glass bulb. When the potential difference (p.d.) across the bulb is sufficient, the filament heats up, emitting visible light.

Fluorescent light bulbs use a long tube of glass containing a small amount of mercury. When a sufficient p.d. is applied across the ends of the tube, electrons moving through the tube cause the mercury to become a vapour and emit photons in the ultraviolet part of the electromagnetic spectrum. The collisions of these photons with the phosphor coating of the tube result in the emission of photons of visible light.
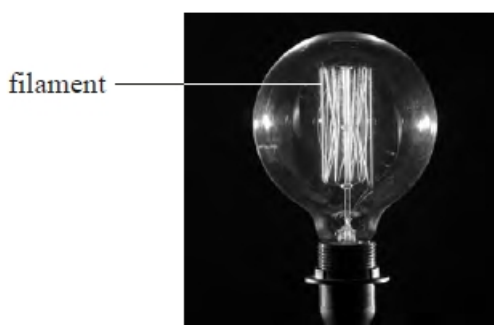


Filament bulb                              Fluorescent bulb

A filament bulb contains a tungsten filament of diameter $3.8 \times 10^{-5}$ m and uncoiled length 1.6 m. As the temperature of the filament increases, the resistance of the filament increases to a maximum which is 14 times greater than the initial resistance at room temperature.

(i) Determine the power of the filament at maximum brightness.

   p.d. across filament = 240 V
   resistivity of tungsten at room temperature = $5.6 \times 10^{-8}$ Ω m

**(5)**

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Power = ...........................................................

(ii) Filament bulbs are designed to last for thousands of hours of use. Over time the filament may wear away, becoming thinner at one point. This can cause the filament to melt and break at that point.

Assess whether the filament is more likely to break as the bulb is switched on or when it is in use.

(4)

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**(Total for question = 9 marks)**

**Q41.**

A torch is switched on for 5 minutes. The current in the torch bulb is 6 mA.

Which of the following gives the charge, in coulombs, that flows in this time?

☒ **A** $6 \times 10^{-3} \times 5$

☒ **B** $\dfrac{6 \times 10^{-3}}{5}$

☒ **C** $\dfrac{6}{300}$

☒ **D** $6 \times 10^{-3} \times 300$

**(Total for question = 1 mark)**

**Q42.**

A potential difference $V$ is applied across the ends of a conductor. The drift velocity of the charge carriers in the conductor is $v$.

Which of the following expressions gives the relationship between drift velocity and potential difference?

☒ **A** $v \propto \dfrac{1}{V}$

☒ **B** $v \propto \dfrac{1}{V^2}$

☒ **C** $v \propto V$

☒ **D** $v \propto V^2$

**(Total for question = 1 mark)**

**Q43.**

A "metre bridge" is a circuit which can be used to measure an unknown resistance accurately. The metre bridge includes a metre length of nichrome wire.

Calculate the resistance of a 1.00 m length of the nichrome wire.

(3)

resistivity of nichrome = $1.12 \times 10^{-6}$ Ωm
 diameter of wire = $4.00 \times 10^{-4}$ m

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Resistance = ...........................................................

**(Total for question = 3 marks)**

**Q44.**

Which of the following is the SI base unit for resistance?

☒ **A**   Ω

☒ **B**   V A$^{-1}$

☒ **C**   kg m$^2$ s$^{-3}$ A$^{-2}$

☒ **D**   kg m$^2$ s$^{-1}$ C$^{-2}$

**(Total for question = 1 mark)**

**Q45.**

The graph shows how the resistance of a light dependent resistor (LDR) varies with the incident light intensity, measured in lux.
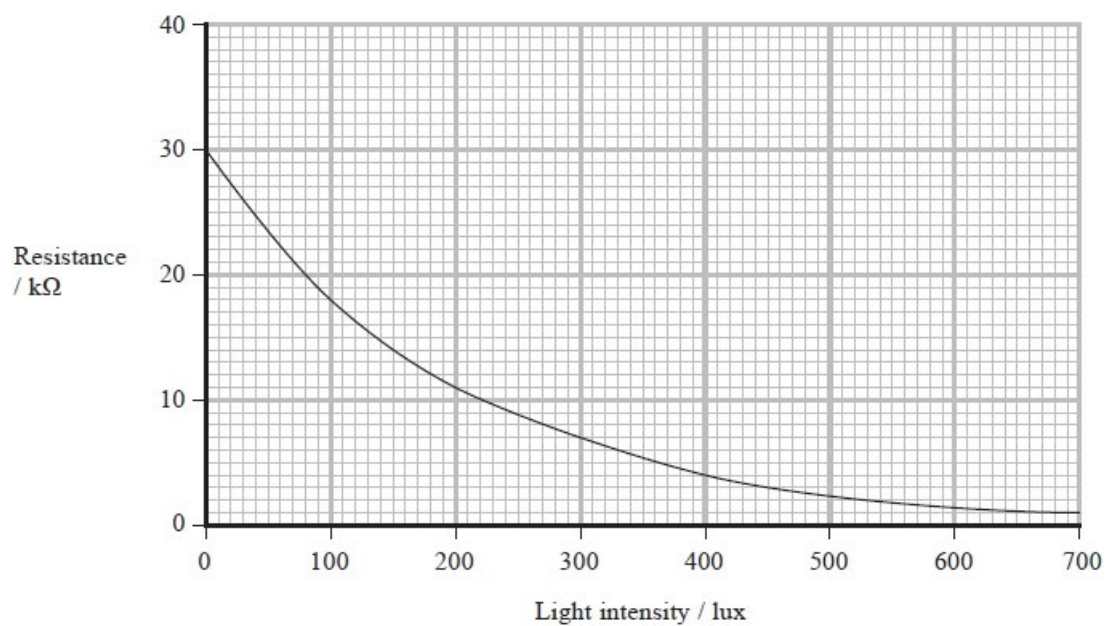


A student used the LDR in the light-sensing circuit shown below.
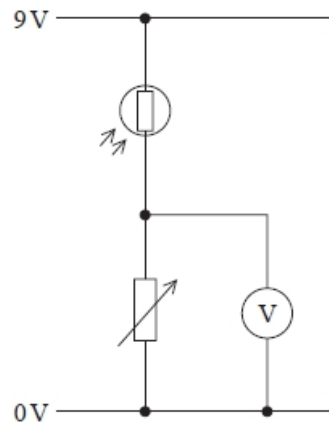
The variable resistor was set at a resistance of 4.5 kΩ.

Determine the light intensity when the potential difference shown on the voltmeter was 2.5 V.

(3)

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Ligt intensity = .......................................................... lux

**(Total for question = 3 marks)**

**Q46.**

The graph shows how the resistance of a light dependent resistor (LDR) varies with the incident light intensity, measured in lux.
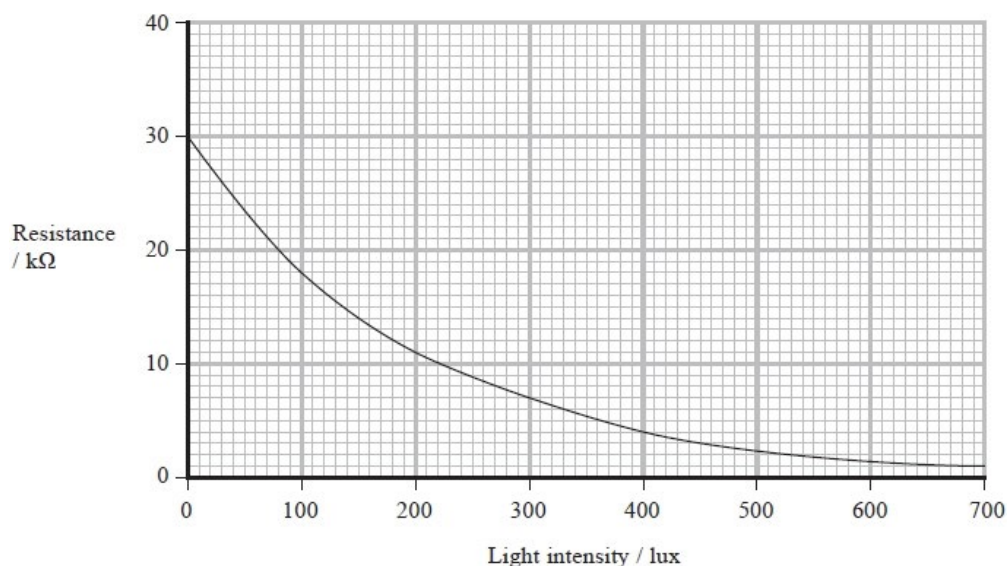


A student used the LDR in the light-sensing circuit shown below.
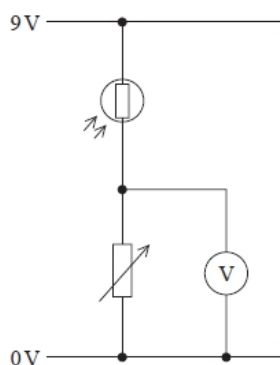


The student increased the resistance of the variable resistor whilst the light intensity was constant. The voltmeter recorded the potential difference across the variable resistor.

Explain what happened to the reading on the voltmeter.

(3)

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**(Total for question = 3 marks)**

**Q47.**

A variable resistor is connected in a circuit as shown. The cell has internal resistance.
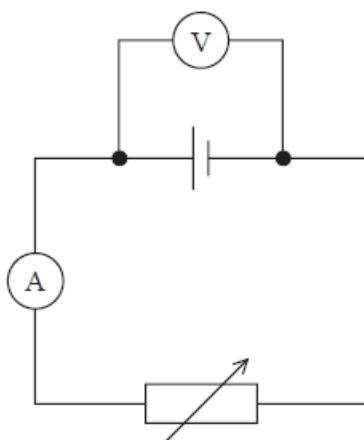


The resistance of the variable resistor is increased.

Which row of the table is correct?

|  | | Ammeter reading | Voltmeter reading |
|---|---|---|---|
| ☒ | A | increases | increases |
| ☒ | B | increases | decreases |
| ☒ | C | decreases | increases |
| ☒ | D | decreases | decreases |

**(Total for question = 1 mark)**

**Q48.**

A student wants to investigate how the resistance $R$ of a negative temperature coefficient thermistor varies with its temperature $T$.

The following graph was plotted from the results of another student's experiment for the same topic.
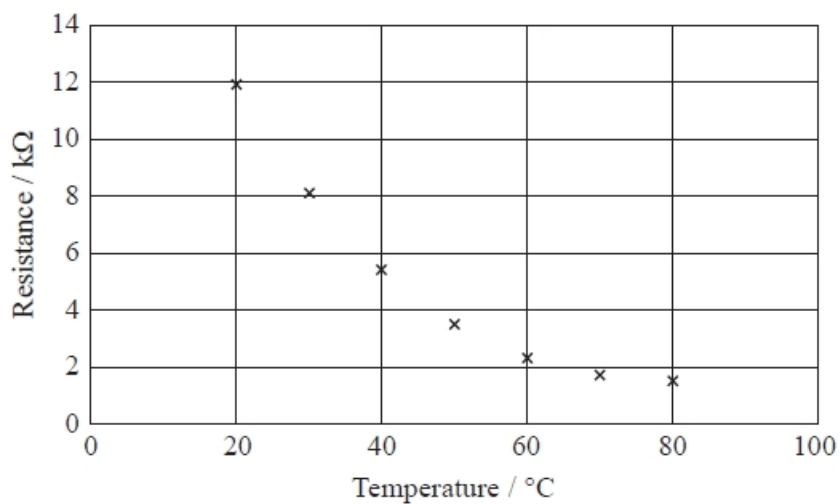


Explain, in terms of particle behaviour, why the resistance of the thermistor decreases as temperature increases.

(4)

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**(Total for question = 4 marks)**

**Q49.**

A student set up the circuit below and moved a sliding contact along a uniform conducting wire.

The student recorded the potential difference *V* across each length of wire *l* under test.
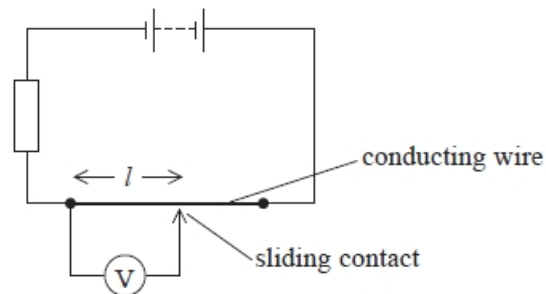


Which graph correctly shows how *V* varies with *l*?

(1)
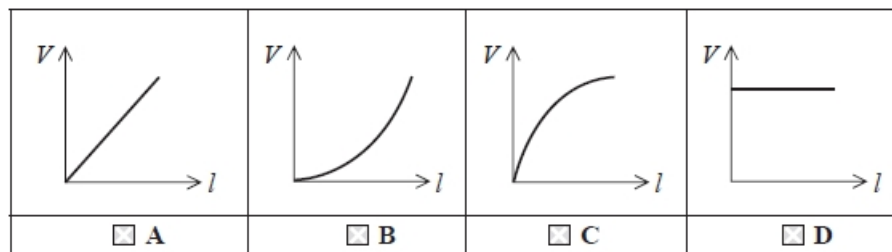


**(Total for question = 1 mark)**

**Q50.**

The graph shows the variation of current *I* with potential difference *V* for a diode.
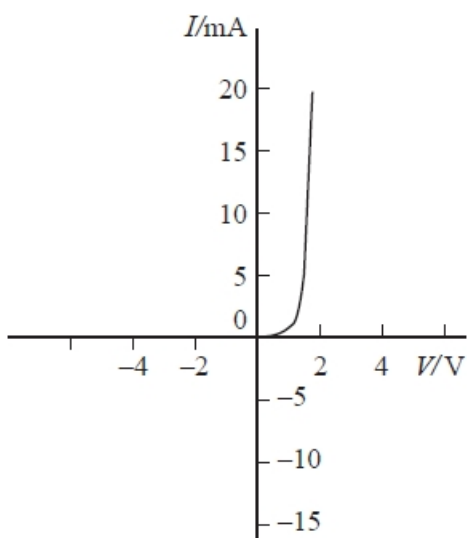


Which of the following statements is correct?

☒ **A**   The diode has zero resistance when connected in the forward direction.
☒ **B**   The diode has zero resistance when connected in the reverse direction.
☒ **C**   The diode starts to conduct when the potential difference is about 0.7 V.
☒ **D**   The diode stops conducting when the potential difference is about −0.7 V.

**(Total for question = 1 mark)**

**Q51.**

A student was given a block of conducting putty of mass 43 g.

(i)  Show that the volume of the block of conducting putty was about $8 \times 10^{-6}$ m$^3$.

density of conducting putty = 5300 kg m$^{-3}$

(2)

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(ii) The student formed the putty into a cylinder. Coins were pushed onto the ends of the cylinder as shown. The coins each had a crocodile clip attached and an ohmmeter was connected across the putty.
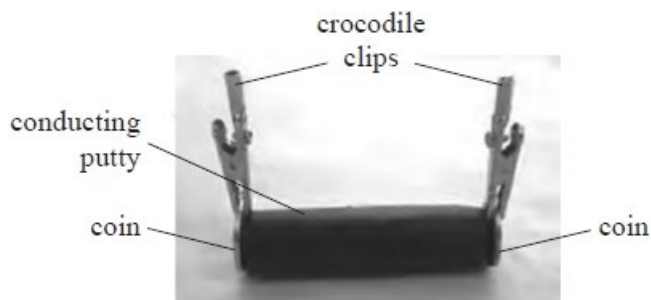


Determine the resistance of the cylinder of putty.
diameter of cylinder = 12 mm
resistivity of conducting putty = $4.0 \times 10^{-3}$ Ω m

(3)

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Resistance = ...........................................................

**(Total for question = 5 marks)**

**Q52.**

A student carried out an experiment to investigate the current-potential difference characteristics of a diode using the circuit below.
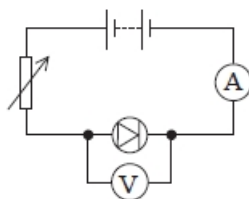


He plotted the graph of potential difference *V* on the *y*-axis against the corresponding current *I* on the *x*-axis.

Which graph would be obtained by the student?

(1)



**(Total for question = 1 mark)**

# Mark Scheme – Electrical Quantities and Components

**Q1.**

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| | • Use of $P = \dfrac{V^2}{R}$ (1) <br><br> • Use of resistance per unit length (1) <br><br> • $l = 9.3$ m (1) | Example of calculation <br><br> $P = \dfrac{(230\ \text{V})^2}{65\ \text{W}} = 813.8$ m <br><br> $l = \dfrac{813.8\ \text{m}}{87.5\ \Omega\ \text{m}^{-1}} = 9.30$ m | 3 |

**Q2.**

| Question Number | Acceptable Answer | | Additional Guidance | Mark |
|---|---|---|---|---|
| (i) | • The IV graph of an ohmic conductor is a straight line through the origin <br> **Or** V is directly proportional to $I$ | (1) | MP1 accept converse argument <br><br> MP2 dependent on MP1 | |
| | • Hence Ohm's law is not obeyed for the LED | (1) | | 2 |

| Question Number | Acceptable Answer | | Additional Guidance | Mark |
|---|---|---|---|---|
| (ii) | **Either** <br> • $V_{LED} = 2$ V (from graph) | (1) | Example of calculation: <br> $2\,\text{V} + V_R = 5\,\text{V}$ | |
| | • Use of $V_{LED} + V_R = 5\,\text{V}$ | (1) | $\therefore V_R = 3\,\text{V}$ | |
| | • Use of $R = \dfrac{V}{I}$ | (1) | $R = \dfrac{3\,\text{V}}{18 \times 10^{-3}\,\text{A}} = 167\,\Omega$ | |
| | • $R = 170\ \Omega$ | (1) | | |
| | **Or** <br><br> • Use of $R = \dfrac{V}{I}$ | (1) | | |
| | • $V_{LED} = 2$ V (from graph) | (1) | | |
| | • Use of $R_{LED} + R = 278\,\Omega$ | (1) | | |
| | • $R = 170\ \Omega$ | (1) | | 4 |

**Q3.**

| Question Number | Acceptable answers | Additional guidance | Mark |
|---|---|---|---|
| | • use of $V = IR$ for the ammeter (1)<br><br>• calculates current through the shunt (1)<br><br>• Shunt resistance = $9.0 \times 10^{-3}$ ($\Omega$) (dependent on MP2) (1)<br><br>Alternative if using $1/R$ rule for parallel resistors<br><br>• use of $V = IR$ for the ammeter<br><br>• Calculates equivalent resistance of the circuit<br><br>• Uses $1/R$ rule to calculate shunt resistance = $9.0 \times 10^{-3}$ ($\Omega$) | Example of calculation:<br>$V = 1.0 \times 10^{-3}$ A $\times 18$ $\Omega = 0.018$ V<br>$I = 2.0A - 0.001 A = 1.999$ A<br>$R = \frac{0.018\,V}{1.999\,A} = 9.0 \times 10^{-3}$ $\Omega$<br><br><br>Alternative:<br><br>$V = 1.0 \times 10^{-3}$ A $\times 18$ $\Omega = 0.018$ V<br><br>$R_T = \frac{0.018\,V}{2A} = 0.009$ $\Omega$<br><br>$\frac{1}{0.009} = \frac{1}{18} + \frac{1}{R_S}$<br>$R_S = 9.0 \times 10^{-3}$ $\Omega$ | **3** |

**Q4.**

| Question Number | Acceptable Answer | Additional Guidance | |
|---|---|---|---|
| | An explanation that makes reference to the following points:<br><br>• The number of (free) charge carriers (per unit volume) in the thermistor decreased (1)<br><br>• (Hence) the resistance of the thermistor increased (1)<br><br>• And a larger fraction of supply p.d. is across the thermistor (1) | MP1: Electrons okay for charge carriers<br><br><br><br>MP3: Current in circuit decreases, so p.d. across fixed resistor decreases, therefore p.d. across thermistor increases | **3** |

**Q5.**

| Question Number | Acceptable answers | Additional guidance | Mark |
|---|---|---|---|
| | • Use of efficiency = output energy / input energy (1)<br><br>• With energy output = load × change in height (1)<br><br>• Energy input $= IVt$ (1) | May be answered in terms of power<br>For MP1 & MP2 accept electrical energy for energy input and work done/GPE for energy output<br>Answers can be in terms of headings from table or cell numbers or values<br><br>Example of calculation<br>$\Delta E_{grav} = 4.00$ N $\times 0.825$ m $= 3.30$ J<br>$W = 2.1$ A $\times 4.3$ V $\times 2.19$ s $= 19.8$ J<br>Efficiency $= \frac{3.30\,J}{19.8\,J} = 0.167$ | **3** |

**Q6.**

| Question Number | Acceptable Answer | | Additional Guidance | Mark |
|---|---|---|---|---|
| | • Ohm's law requires current to be (directly) proportional to the (applied) p.d | (1) | For MP1 accept Ohm's law requires $I \propto V$ | 4 |
| | • Hence the line should pass through the origin | (1) | In MP2, credit students who check values from graph to see if $I$ doubles when $V$ doubles | |
| | • (There is scatter around the line drawn by the student so) the correct line may be a curve | (1) | In MP3, credit students who draw a curve onto the graph<br><br>MP4 dependent upon MP2 OR MP3 | |
| | • Conclusion that this graph does not meet the conditions for Ohm's law so the student's statement is invalid | (1) | | |

**Q7.**

| Question Number | Answer | | Additional Guidance | Mark |
|---|---|---|---|---|
| (i) | • Calculation of mean | (1) | Example of calculation | 3 |
| | • Use of half range Or maximum difference from the mean | (1) | $$\bar{d} = \frac{(1.40+1.44+1.42+1.41)\ \text{mm}}{4}$$ $$=1.42\ \text{mm}$$ | |
| | • % uncertainty = 1.4% | (1) | $$\%U = \frac{(1.44 - 1.40)\ \text{mm}/2}{1.42\ \text{mm}} \times 100\%$$ $$=1.41\%$$ | |
| (ii) | • Use of $A = \pi r^2$ | (1) | Example of calculation | 3 |
| | • Use of $R = \frac{\rho l}{A}$ | (1) | $$A = \pi \left(\frac{1.42 \times 10^{-3}\text{m}}{2}\right)^2 =$$ $$1.58 \times 10^{-6}\ \text{m}^2$$ | |
| | • $\rho = 6.9 \times 10^{-7}$ ($\Omega$ m), so wire is made from stainless steel | (1) | $$\rho = \frac{0.72\ \Omega \times 1.58 \times 10^{-6}\ \text{m}^2}{1.65\ \text{m}} =$$ $$6.9 \times 10^{-7}\ \Omega\,\text{m}$$ | |

**Q8.**

| Question Number | Acceptable answers | | Additional guidance | Mark |
|---|---|---|---|---|
| | • Use of $\pi r^2$ or $\pi d^2/4$ | (1) | Example of calculation | |
| | | | Cross sectional area $= \pi \frac{(12.2 \times 10^{-8}\, \text{m})^2}{4} = 1.2 \times 10^{-4}\, \text{m}^2$ | |
| | • Use of $I = nAvq$ | (1) | $1.9\, \text{A} = 1.7 \times 10^{29}\, \text{m}^{-3} \times 1.2 \times 10^{-4}\, \text{m}^2 \times v \times 1.6 \times 10^{-19}\, \text{C}$ | |
| | • $v = 5.8$ to $6.0 \times 10^{-7}$ m s$^{-1}$ | (1) | $v = 5.8 \times 10^{-7}$ m s$^{-1}$ | 3 |

**Q9.**

| Question Number | Acceptable Answer | | Additional Guidance | Mark |
|---|---|---|---|---|
| | • Use of $A = \pi r^2$ with $r$ | (1) | MP3 accept $R = 18.15\, \Omega$ | |
| | • Use of $R = \frac{\rho L}{A}$ | (1) | MP3. Allow calculation of $\rho$ using given values and subtraction of total % uncertainty. | |
| | • With at least one of the following values | (1) | Example of calculation: | |
| | $R = 18.1\, \Omega$  $L = 1.30$ m | (1) | $A = \pi r^2 = \pi \times (0.13 \times 10^{-3}\, \text{m})^2 = 5.31 \times 10^{-8}\, \text{m}^2$ | |
| | $A = \pi \times (0.13 \times 10^{-3}\, \text{m})^2$ | | $\rho = \frac{RA}{L} = \frac{18.1\Omega \times 5.31 \times 10^{-8}\, \text{m}^2}{1.30\, \text{m}} = 7.39 \times 10^{-7}\, \Omega\, \text{m}$ | |
| | • $\rho = (7.3 \rightarrow 7.4) \times 10^{-7}\, \Omega\text{m}$ | | | 4 |

**Q10.**

| Question Number | Acceptable answers | | Additional guidance | Mark |
|---|---|---|---|---|
| | • Use of $P = VI$ for panel | (1) | Example of calculation: | 3 |
| | • Use of $P = \frac{E}{t}$ | (1) | Total Power of panels= $380 \times 5.5\, \text{V} \times 0.45\, \text{A} = 940.5\, \text{W}$ | |
| | • Time = 13 hours | (1) | Time to charge $= 12000 / 940.5 = 12.8$ hours | |

**Q11.**

| Question Number | Acceptable Answer | Additional Guidance | Mark |
|---|---|---|---|
| | • use of $\Delta E_{grav} = mg\Delta h$ and use of $P = VI$ **(1)**<br>• correct use of time **(1)**<br>• efficiency = 0.816 or 81.6 % **(1)** | Example of calculation:<br><br>$\Delta E_{grav}$ = 800 kg × 9.81 m s$^{-2}$ × 14 m/s = 109900 J<br>$P$ = 230 V × 13.0 A = 2990 W<br>$E = Pt$ = 2990 W x 45 s = 134600 J<br>efficiency = 109900 J/134600 J = 0.816<br><br>Alternative calculation:<br><br>$Efficiency = \dfrac{\left(800\ kg \times 9.81\ N kg^{-1} \times 14\ m\right)/45.0\ s}{230\ V \times 13.0\ A} = 0.816$<br><br>Accept rounding variations if alternative calculation method used. | 3 |

**Q12.**

| Question number | Acceptable answers | Additional guidance | Mark |
|---|---|---|---|
| | • $R_T$ = 0.7 − 0.8 kΩ [read from graph] **(1)**<br>• Use of $V=IR$ (with 3.5 V and $R_T$) to find $I$ **and** $V=IR$ (with $V$ = 5.5 $V$) to find $R$ **(1)**<br>• $R$=1100 − 1300 Ω **(1)** | Accept use of<br><br>$Vo = Vs\left(\dfrac{R_1}{R_1 + R_2}\right)$<br><br>Or<br><br>$V_{out}/(V_s − V_{out})$ x $R_T = R$<br><br>Example of calculation:<br>$I = \dfrac{3.5}{750} = 0.0047$ A<br><br>$R = \dfrac{5.5}{0.0047} = 1170\ Ω$ | 3 |

**Q13.**

| Question number | Acceptable answers | Additional guidance | Mark |
|---|---|---|---|
| (a) | • Use of: <br> $$R = \frac{\rho L}{A} \text{ (1)}$$ <br> • $\frac{R_B}{R_A} = 0.5$ [accept 2:4 **or** 1:2 **or** 1/2] **(1)** | Example of calculation: <br> $$\frac{R_B}{R_A} = \frac{L_2 d_1^2}{L_1 d_2^2}$$ <br> $$\frac{R_B}{R_A} = \frac{2Ld^2}{L(2d)^2} = \frac{2}{4} = 0.5$$ | **2** |
| (b) | • Correct transfer of data for gradient **(1)** <br> • Large triangle used **(1)** <br> • $\rho = 1.1 \times 10^{-4}$ Ωm **(1)** <br><br> Conclusion: <br> • $1.1 \times 10^{-4}$ Ωm is greater than $3 \times 10^{-5}$ Ωm, so resistivity increases when clay is added **(1)** | Answer to be consistent with calculated value. <br><br> Example of calculation: <br> Gradient $= \rho L = 16.5 \times 10^{-6}$ Ωm² <br> $\rho = 16.5 \times 10^{-6}$ Ωm²/0.15 m $= 1.1 \times 10^{-4}$ Ωm | **4** |

**Q14.**

| Question Number | Acceptable answers | Additional guidance | Mark |
|---|---|---|---|
| | • The (voltmeter) reading will increase **(1)** <br><br> • Resistance increases (with length) **Or** <u>resistance</u> ∝ length **(1)** | MP2: accept idea of a potential divider i.e. the ratio of the of BC to the total length AD will be greater, so the proportion of the total voltage will be greater ($\frac{BC}{AD}$ V) <br><br> MP2: Do not award if there is also a reference to resistivity increasing | **2** |

**Q15.**

| Question Number | Answer | Mark |
|---|---|---|
| | **D   1080 C** | **1** |
| | Incorrect Answers: <br> A – current divided by time, with the time in seconds <br> B – current divided by time, with the time in minutes <br> C – correct formula of current × time but the time is in minutes and not seconds | |

**Q16.**

| Question Number | Answer | Mark |
|---|---|---|
| | B  filament bulb | 1 |
| | Incorrect Answers:<br>A – this is not the graph for a diode<br>C – this is not the graph for an ohmic resistor<br>D – this is not the graph for a thermistor | |

**Q17.**

| Question Number | Answer | Mark |
|---|---|---|
| | A  dark and cold | 1 |
| | Incorrect Answers:<br>B – correct description for LDR but incorrect for thermistor<br>C – incorrect description for LDR but correct for thermistor<br>D – incorrect description for LDR and incorrect for thermistor | |

**Q18.**

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| | • Use of Area = width × thickness  (1)<br><br>• Use of $R = \frac{\rho l}{A}$  (1)<br><br>• thickness = $9.4 \times 10^{-4}$ m  (1) | Example of calculation:<br><br>$12 \times 10^3 \Omega = \dfrac{0.49\ \Omega\ \text{m} \times 0.115\ \text{m}}{0.0050\ \text{m} \times t}$<br><br>thickness = $9.4 \times 10^{-4}$ m | 3 |

**Q19.**

| Question Number | Acceptable answers | Additional guidance | Mark |
|---|---|---|---|
| | • As temperature increases number of (free) charge carriers (in thermistor) increases so its resistance decreases<br>**Or**<br>As temperature increases number of charge carriers in conduction band increases so (thermistor) resistance decreases (1)<br><br>• Thermistor resistance as a proportion of total resistance decreases (1)<br>**Or** (1)<br>Current increases so p.d. across resistor increases<br><br>• P.D. (across thermistor) decreases | Accept electrons for charge carriers | 3 |

**Q20.**

| Question Number | Acceptable answers | Additional guidance | Mark |
|---|---|---|---|
| | C | | 1 |

**Q21.**

| Question Number | Acceptable answers | Additional guidance | Mark |
|---|---|---|---|
| | **The only correct answer is A**<br><br>B *is not correct because V decreases as I decreases*<br>C *is not correct because I decreases as R increases*<br>D *is not correct because I decreases as R increases* | decreases decreases | 1 |
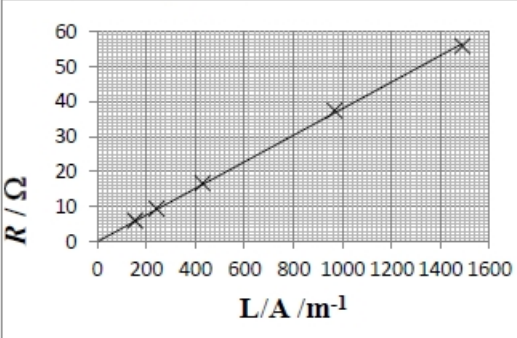
**Q22.**

| Question Number | Acceptable answers | Additional guidance | Mark |
|---|---|---|---|
| | A The p.d. across the resistor added to the p.d. across the thermistor must equal 6 V. This occurs when the current is 0.5 A. | 0.5 | 1 |
| | B assumes all the p.d. is across the thermistor<br>C assumes that resistor and thermistor connected in parallel<br>D assumes that the p.d. across the resistor and thermistor is more than 6 V | | |

**Q23.**

| Question Number | Answer | Mark |
|---|---|---|
| | **B   thermistor graph** | 1 |
| | Incorrect Answers:<br>A – ohmic conductor graph<br>C – filament lamp graph<br>D – diode graph | |

**Q24.**

| Question Number | Acceptable Answer | Additional Guidance | Mark |
|---|---|---|---|
| (a)(i) | • axes and labels          (1)<br><br>• suitable scale          (1)<br><br>• all points plotted          (1)<br>  correctly<br><br>• line of best fit drawn (1) | Example of graph:<br> | (4) |
| (a)(ii) | • attempt to measure   (1)<br>  gradient using large<br>  triangle<br><br>• $\rho$ = (0.035 – 0.041) (1)<br>  $\Omega$m to 2 sf | | (2) |

| Question Number | Acceptable Answer | | Additional Guidance | Mark |
|---|---|---|---|---|
| **(b)** | Two problems identified with solutions from: | | Accept micrometer giving precision of 0.01 mm for diameter | |
| | • taking only one reading could produce an unreliable result | (1) | | |
| | • so take repeat readings of length and diameter | (1) | | |
| | • metre ruler cannot be used to measure the diameter with sufficient precision<br><br>OR metre rule can only measure diameter at ends of cylinder | (1) | | |
| | • so use Vernier callipers instead | (1) | | |
| | • comment about non-uniform shape | (1) | | |
| | • so take repeat readings at different positions/ orientations | (1) | | **(4)** |

**Q25.**

| Question Number | Acceptable answers | Additional guidance | Mark |
|---|---|---|---|
| | C | joule per coulomb. | 1 |
| | Incorrect Answers:<br>A is reciprocal of volt<br>B is definition of amp<br>D is definition of watt | | |

**Q26.**

| Question number | Acceptable answers | Additional guidance | Mark |
|---|---|---|---|
| | D | | 1 |

**Q27.**

| Question Number | Acceptable Answer | Additional Guidance | Mark |
|---|---|---|---|
| | An explanation that makes reference to:<br><br>• amplitude of lattice vibration increases **(1)**<br><br>• resulting in more frequent collisions of electrons with lattice ions **(1)**<br>• so this results in a smaller (mean) drift velocity $I=nAve$ and consequently the current decreases **(1)** | Must be the idea of a greater frequency of collisions, not just a greater number of collisions. Do not accept collisions between electrons.<br><br>MP3 dependent on MP1 and MP2 | 3 |

**Q28.**

| Question Number | Acceptable answers | Additional guidance | Mark |
|---|---|---|---|
| | The only correct answer is B<br><br>| decreases | increases | | C and D are incorrect as the resistance decreases<br>A is incorrect as $n$ increases | 1 |

**Q29.**

| Question number | Acceptable answers | Additional guidance | Mark |
|---|---|---|---|
| | An explanation that makes reference to:<br><br>• A rise in temperature causes the amplitude of the vibrating ions to increase **(1)**<br>• This causes the number of collisions per second between the ions and the moving electrons to increase **(1)**<br>• So the rate of flow of electrons decreases (causing the resistance of the metal to increase) **(1)** | Allow reduce mean free path or drift velocity of electrons.<br><br><br>Accept current decreases | 3 |

**Q30.**

| Question number | Acceptable answers | Additional guidance | Mark |
|---|---|---|---|
| | • The number of charge carriers increases with temperature **(1)**<br>• So this <u>lowers</u> the resistance (despite the increase in lattice vibrations) **(1)** | Accept number of electrons. | 2 |

**Q31.**

| Question Number | Acceptable Answer | Additional Guidance | Mark |
|---|---|---|---|
| | • Use of $P = VI$ Or use of $\triangle E_{grav} = mg\triangle h$   (1)<br><br>• Use of efficiency $= \dfrac{\text{useful power output}}{\text{total power input}}$   (1)<br><br>• Efficiency = 0.75 to 0.78 (or 75 % to 78%)   (1) | Accept use of efficiency $= \dfrac{\text{useful energy output}}{\text{total energy input}}$ with corresponding times<br><br>Example of calculation<br><br>$P_{motor} = (85 \times 10^{-3})$ A $\times 3.0$ V $= 0.255$ W<br><br>$P_{block} = 0.05$ kg $\times 9.81$ N kg$^{-1} \times 0.40$ m s$^{-1} = 0.196$ W<br><br>Efficiency $= \dfrac{0.196 \text{ W}}{0.255 \text{ W}} = 0.77$ (no unit) | 3 |

**Q32.**

| Question Number | Acceptable Answer | Additional Guidance | Mark |
|---|---|---|---|
| | • The replacement charger will still have to supply the same charge (6510 C)   (1)<br><br>• The replacement charging plug takes more time to charge Or the old charging plug takes less time to charge   (1)<br><br>• Replacement charging plug uses a lower current therefore reduces heating effect   (1)<br><br>• The phone may try and draw a current of 1 A which may damage the charging plug   (1) | MP1: may be awarded for use of 6510 C in a calculation for MP2<br><br>MP2 calculation to support this using t = Q/I Or if the phone uses 1A the time to charge will be the same | 4 |

**Q33.**

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| | **B is the only correct answer** | A is incorrect because amplitude does increase<br>C is incorrect because rate of collision does increase<br>D is incorrect because rate of energy transfer does increase | 1 |

**Q34.**

| Question Number | Acceptable answers | | Additional guidance | Mark |
|---|---|---|---|---|
| | • Use of $\pi r^2$ | (1) | | |
| | • Use of $R = \rho l/A$ | (1) | | |
| | • Length = 0.056 m | (1) | Example of calculation: Area $= \pi(0.95 \times 10^{-3}\text{m})^2 = 2.8(4)\times 10^{-6}$ m$^2$ $l = \frac{9.0\times 10^{-3}\,\Omega \times 2.8(4)\times 10^{-6}\,\text{m}^2}{4.55\times 10^{-7}\,\Omega\,\text{m}} = 0.0\,56$ m "Show that" value $l = 0.062$ m | 3 |

**Q35.**

| Question Number | Acceptable answers | Additional guidance | Mark |
|---|---|---|---|
| | The only correct answer is B A *is not correct because R decreases as more conduction electrons* C *is not correct because lattice vibrations not affected* D *is not correct because lattice vibrations not affected* | It increases because there is an increase in the number of conduction electrons. | 1 |

**Q36.**

| Question Number | Acceptable answers | Additional guidance | Mark |
|---|---|---|---|
| | The only correct answer is B A is not correct as the p.d. across the resistor will increase C is not correct as the resistance of the LDR will decrease D is not correct as the resistance of the LDR will decrease | | 1 |

**Q37.**

| Question Number | Acceptable Answers | | Additional guidance | Mark |
|---|---|---|---|---|
| | • Uses ratio of resistances to pd's Or uses $I = \frac{V}{R_{total}}$ and $V = IR$ | (1) | $R_{total}$=1750 Ω Example of Calculation $V_o = V_s \left(\frac{R_1}{R_1 + R_2}\right)$ | |
| | • Output pd =13.7 (V) • Compares their answer to 13 (V) with conclusion consistent with their answer | (1) (1) | $V_{LDR} = 24\,V \left(\frac{1000\,\Omega}{750\,\Omega + 1000\,\Omega}\right)$ $= 13.7\,V$ $13.7 > 13$ so motor is on | 3 |

**Q38.**

| Question Number | Acceptable Answer | | Additional Guidance | Mark |
|---|---|---|---|---|
| | • use of $Q = It$ <br> • use of $V = \frac{W}{Q}$ <br> • $W = 5.1 \times 10^8$ J | (1) <br> (1) <br> (1) | Allow calculations based on power i.e. <br> $VI = \frac{W}{t}$ <br><br> Example of calculation: <br> $Q = It = 25 \times 10^3$ A $\times 7.5 \times 10^{-3}$ s $= 188$ C <br> $W = QV = 188$ C $\times 2.7 \times 10^6$ V $= 5.08 \times 10^8$ J | 3 |

**Q39.**

| Question Number | Answer | Mark |
|---|---|---|
| | **D** $\quad \frac{R_2}{R_1+R_2} V$ | 1 |
| | Incorrect Answers: <br> A – this looks similar to the correct formula but has an incorrect resistance as the numerator and does not have the total resistance as the denominator <br> B – this looks similar to the correct formula with the correct resistance as the numerator but does not have the total resistance as the denominator <br> C – This would give the PD across resistor $R_1$ and not $R_2$ | |

**Q40.**

| Question Number | Acceptable answers | | Additional guidance | Mark |
|---|---|---|---|---|
| (i) | • Use of cross-sectional area $= \pi r^2$ Or $\frac{\pi d^2}{4}$ <br><br> • Use of $R = \frac{\rho l}{A}$ <br><br> • Correct use of factor of 14 <br><br> • Use of $P = \frac{V^2}{R}$ <br><br> • $P = 52$ W | (1) <br><br> (1) <br><br> (1) <br><br> (1) <br><br> (1) | Example of calculation <br> $A = \pi(1.9 \times 10^{-5} \text{ m})^2 = 1.134 \times 10^{-9} \text{ m}^2$ <br> $R = \frac{(5.6 \times 10^{-8} \, \Omega m)(1.6 \text{ m})}{1.134 \times 10^{-9} \text{ m}^2} = 79.01 \, \Omega$ <br> $R_{max} = 14 \times 79.01 \, \Omega = 1106.2 \, \Omega$ <br> $P = \frac{(240 \, V)^2}{1106.2 \, \Omega} = 52.1$ W | 5 |

| Question Number | Acceptable answers | | Additional guidance | Mark |
|---|---|---|---|---|
| (ii) | **Either** | | | |
| | • Initially( the resistance is low so) current will be the greatest | (1) | | |
| | • As $P = I^2R$, the greatest power is transferred | (1) | | |
| | | (1) | | |
| | • Change in current has more effect as it is squared | | | |
| | | (1) | | |
| | • Heating effect greatest when R is lowest, so breaks when switched on. | | | |
| | **OR** | (1) | | |
| | | (1) | | |
| | • p.d. is constant | | | |
| | | (1) | | |
| | • $P = V^2/R$ | | | |
| | | (1) | | |
| | • Power is greatest when $R$ is lowest | | | |
| | • Heating effect is greatest when $R$ is lowest, so breaks when switched on | (1) | | |
| | **OR** | (1) | | |
| | | (1) | | |
| | • p.d. is constant | | | |
| | • Initially (resistance is low so) current will be the greatest | (1) | | 4 |
| | • As P=IV the greatest power is transferred | | | |
| | • Heating effect is greatest when $R$ is lowest, so breaks when switched on | | | |

**Q41.**

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| | **D is the only correct answer** | A is incorrect because the time has not been converted to seconds<br>B is incorrect because $Q = It$ and time has not been converted to seconds<br>C is incorrect because $Q = It$ | 1 |

**Q42.**

| Question Number | Acceptable answers | Additional guidance | Mark |
|---|---|---|---|
| | C | | 1 |

**Q43.**

| Question Number | Acceptable answers | Additional Guidance | Mark |
|---|---|---|---|
| | • Use of $R = \dfrac{\rho l}{A}$ (1)<br><br>• Use of area formula with correct value of radius (1)<br><br>• $R = 8.9\ \Omega$ (1) | Use of: any dimensionally correct substitutions eg using a diameter squared<br><br>Accept $R=8.62$ as due to rounding<br>Area<br>Example of calculation:<br>$R =$ 1.12 x 10$^{-6}$ $\Omega$ m x 1m / $\pi(0.2\text{x}10^{-3})^2$ m$^2$ | 3 |

**Q44.**

| Question Number | Answer | Mark |
|---|---|---|
| | C   $kg\,m^2\,s^{-3}\,A^{-2}$ | 1 |
| | Incorrect Answers:<br>A – $\Omega$ is not a base unit<br>B – V is not a base unit<br>D – C is not a base unit | |

**Q45.**

| Question Number | Acceptable answers | | Additional guidance | Mark |
|---|---|---|---|---|
| | • Use $V=IR$ to calculate current<br>• Use $V=IR$ with V = 6.5 V to calculate LDR resistance<br>• Light intensity = 185 (lux) (accept answers in range 180 lux -190 lux)<br><br>**OR**<br><br>• Use of potential divider principle<br><br>• Use of $R_T = R_{LDR} + 4.5k\Omega$ to calculate LDR resistance<br>Or | (1)<br>(1)<br><br>(1)<br><br><br>(1)<br><br><br>(1) | Example of Calculation.<br>2.5 V = $I \times 4.5x10^3$ Ω<br>$I = 5.6 \times 10^{-4}$ A<br><br>6.5 V = $0.56x10^{-3}$ A $\times R$<br>$R = 11700$ Ω | 3 |
| | Use of $V_{LDR}$ = 6.5 V to calculate LDR resistance<br><br>• Light intensity = 185 (lux) (accept answers in range 180 lux -190 lux) | (1) | | |

**Q46.**

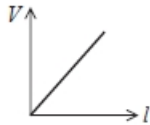| Question Number | Acceptable answers | | Additional guidance | Mark |
|---|---|---|---|---|
| | • Current (in the circuit) decreases<br><br>• P.d. across the LDR decreases<br><br>• Voltmeter reading increases (MP3 dependent on MP1 or MP2) | (1)<br><br>(1)<br><br>(1) | Accept approaches using potential divider theory<br><br>• Pd from supply divides in ratio of resistances of the two components, eg.<br><br>$V_{LDR} = \dfrac{R_{LDR}}{R_R + R_{LDR}} \times V_{Total}$<br><br>• As $R_R$ increases, but $R_{LDR}$ stays constant<br><br>• So voltmeter reading increases (MP3 dependent on MP1) | 3 |

**Q47.**

| Question Number | Answer | Mark |
|---|---|---|
| | **C   ammeter reading decreases, voltmeter reading increases** | 1 |
| | A – the ammeter reading does not increase<br>B – neither occurs<br>D – the voltmeter reading does not decrease | |

**Q48.**

| Question Number | Acceptable answers | Additional guidance | Mark |
|---|---|---|---|
| | • Increased temperature causes more energy transfer to lattice ions / atoms  (1)<br><br>• More charge carriers released / available  (1)<br><br>• $I = nAvq$, so relative increase in $I$  (1)<br><br>• Reference to $R = V / I$ to justify decrease in $R$  (1) | Or reverse argument | 4 |

**Q49.**

| Question Number | Acceptable Answer | Additional Guidance | Mark |
|---|---|---|---|
| | A  | | 1 |

**Q50.**

| Question Number | Answer | Mark |
|---|---|---|
| | C  The diode starts to conduct when the potential difference is about 0.7 V. | 1 |
| | Incorrect Answers:<br>A – The diode has zero resistance when connected in the forward direction<br>B – The diode has zero resistance when connected in the reverse direction.<br>D – The diode stops conducting when the potential difference is about −0.7 V. | |

**Q51.**

| Question Number | Acceptable answers | | Additional guidance | Mark |
|---|---|---|---|---|
| (i) | • Use of $\rho = \frac{m}{V}$ <br><br> • $V = 8.1 \times 10^{-6}$ (m³) | (1) <br><br> (1) | Example of Calculation. <br> $V = \dfrac{0.043 \text{ kg}}{5300 \text{ kgm}^{-3}}$ <br><br> $V = 8.1 \times 10^{-6} \text{ m}^3$ | 2 |
| (ii) | • Use of $A = \pi r^2$ and $V = Al$ <br><br> • Use of $R = \frac{\rho l}{A}$ <br><br> • $R = 2.5 \; \Omega$ (ecf from (a)(i)) | (1) <br><br> (1) <br><br> (1) | Show that value gives 2.50 Ω <br><br> Example of Calculation. <br><br> $A = \pi(6 \times 10^{-3} \text{ mm})^2 = 1.13 \times 10^{-4}$ m² <br><br> $8.1 \times 10^{-6} \text{ m}^3 = (1.13 \times 10^{-4} \text{ m}^3) \, l$ <br> $l = 0.0716 \text{ m}$ <br><br> $R = \dfrac{(4.0 \times 10^{-3} \; \Omega \text{ m})(0.0716 \text{ m})}{(1.13 \times 10^{-4} \text{ m}^3)}$ <br><br> $R = 2.54 \; \Omega$ | 3 |

**Q52.**

| Question Number | Acceptable Answer | Additional Guidance | Mark |
|---|---|---|---|
| | C     | | 1 |