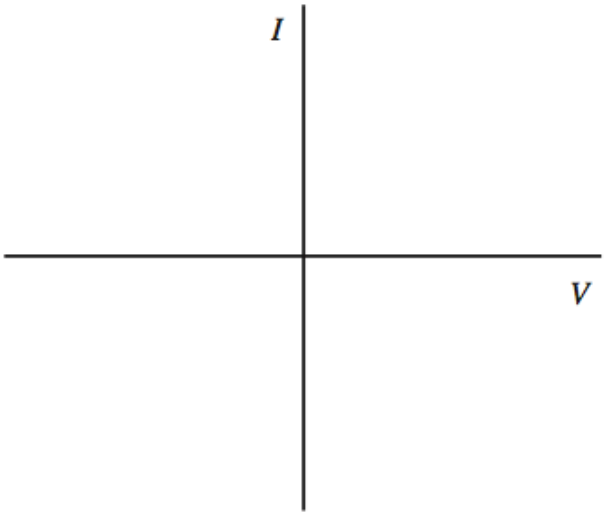
1)

(a) Sketch, on **Figure 1**, the current–voltage (IV) characteristic for a filament lamp for currents up to its working power.

[2 marks]

Figure 1



(b) (i) State what happens to the resistance of the filament lamp as the current increases.

[1 mark]

.....

(b) (ii) State and explain whether a filament lamp is an ohmic or non-ohmic conductor up to its working power.

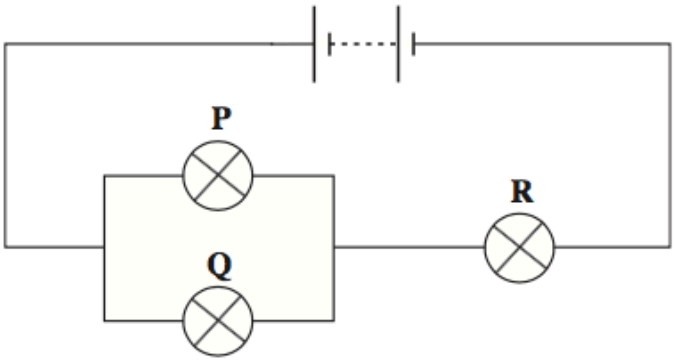
[1 mark]

.....

.....

(c) Three identical filament lamps, **P**, **Q** and **R** are connected in the circuit shown in **Figure 2.**

Figure 2



The filament in lamp **Q** melts so that it no longer conducts. Explain why lamp **P** becomes brighter and lamp **R** becomes dimmer.

[2 marks]

.....

.....

.....

.....

.....

.....

(d) A filament lamp, **X**, is rated at 60 W 230 V. Another type of lamp, **Y**, described as 'energy saving' has the same light intensity output but is rated at 11 W 230 V.

(d) (i) Calculate the electrical energy converted by each lamp if both are on for 4 hours a day for a period of 30 days.

[2 marks]

electrical energy converted by **X** = ... J

electrical energy converted by **Y** = ... J

(d) (ii) Suggest why the two lamps can have different power ratings but have the same light intensity output.

[2 marks]

.....

.....

.....

.....

.....

2)

An experiment can be performed to determine whether a particular component is an ohmic conductor.

(a) State what is meant by an ohmic conductor.

.....

(1 mark)

(b) (i) Draw a suitable circuit diagram for such an experiment.

(2 marks)

(b) (ii) For the circuit diagram you have drawn, describe a suitable experiment. Your account should include details of:

- what measurements you would take
- how you would use your measurements
- how you would reach a conclusion.

The quality of written communication will be assessed in your answer.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(6 marks)

(c) (i) State the principal property of a superconductor.

.....

.....

(1 mark)

(c) (ii) State what is meant by critical temperature.

.....

.....

(1 mark)

(c) (iii) Give **one** use of a superconductor.

.....

.....

(1 mark)

3)

(a) Some materials exhibit the property of *superconductivity* under certain conditions.

- State what is meant by superconductivity.
- Explain the required conditions for the material to become superconducting.

.....

.....

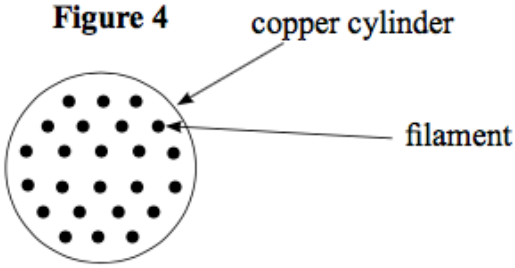
.....

.....

(3 marks)

(b) **Figure 4** shows the cross-section of a cable consisting of parallel filaments that can be made superconducting, embedded in a cylinder of copper.

Figure 4



(b) (i) The cross-sectional area of the copper in the cable is $2.28 \times 10^{-7} m^2$. The resistance of the copper in a 1.0m length of the cable is 0.075Ω. Calculate the resistivity of the copper, stating an appropriate unit.

answer = ...

(3 marks)

(b) (ii) State and explain what happens to the resistance of the cable when the embedded filaments of wire are made superconducting.

.....

.....

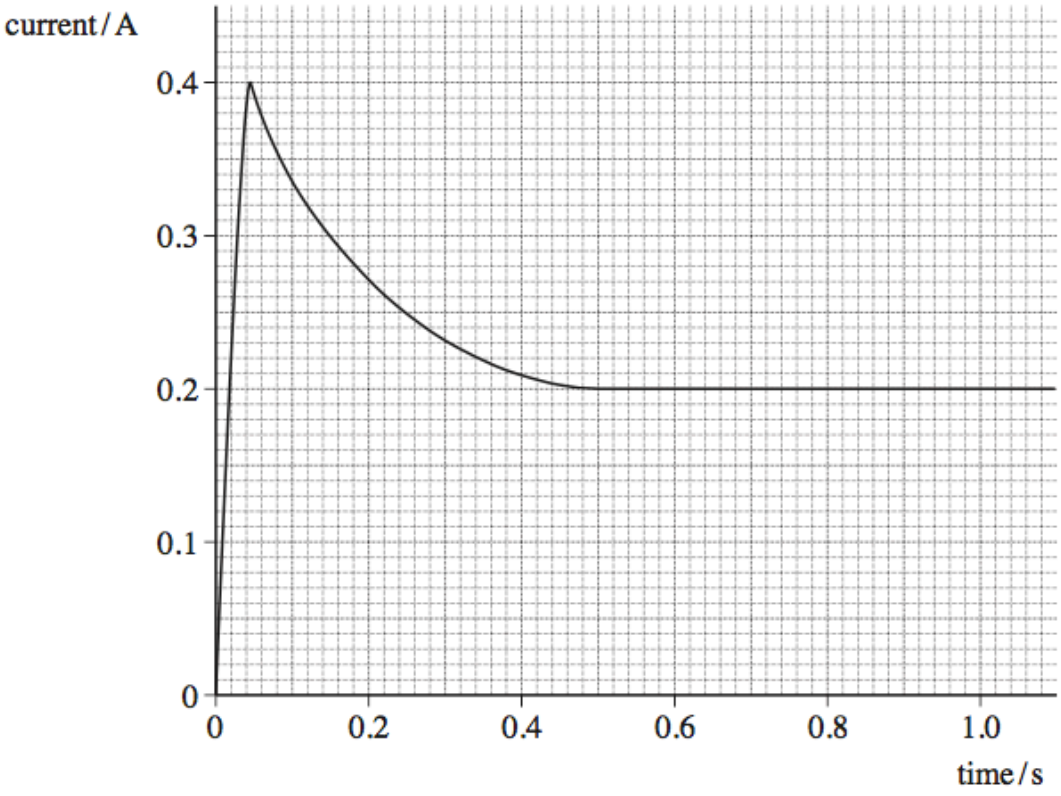
.....

(3 marks)

4)

When a filament lamp is switched on it takes 0.50 seconds for the filament to reach its normal operating temperature. The way in which the current changes during the first second after switching on is shown on the graph in **Figure 2**.

Figure 2



(a) Use the graph to determine the maximum current through the lamp.

answer = ... A

(1 mark)

(b) Assuming that the lamp is connected to a 12 V dc supply of a negligible internal resistance,

(b) (i) Calculate the resistance of the lamp when it has reached its normal operating temperature,

answer = ... Ω

(1 mark)

(b) (ii) Calculate the power of the lamp when it has reached its normal operating temperature.

answer = ... W

(1 mark)

(c) Explain why the current through the lamp decreases between 0.05 s and 0.50 s.

.....

.....

.....

.....

.....

.....

(2 marks)

(d) State and explain the change, if any, to the final current through the lamp if it is connected to the same supply with another similar lamp

(d) (i) in series,

.....

.....

.....

.....

(2 marks)

(d) (ii) in parallel.

.....

.....

.....

.....

(2 marks)

(e) State and explain why a filament lamp is most likely to fail as it is switched on.

.....

.....

.....

.....

(2 marks)

5)

(a) A semiconducting diode is an example of a *non-ohmic* component. State what is meant by a non-ohmic component.

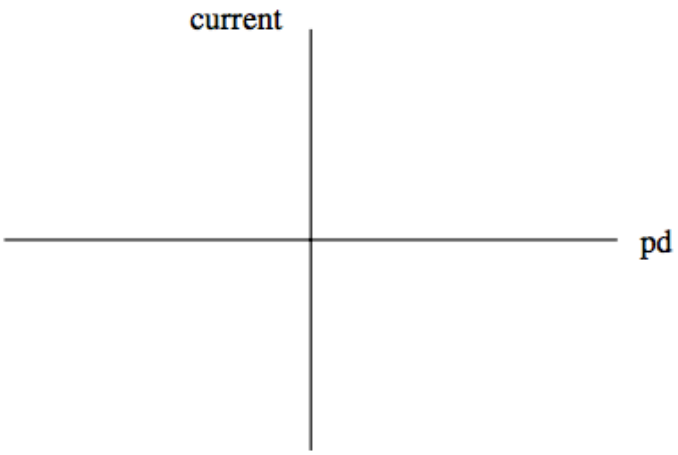
.....

.....

(1 mark)

(b) A filament lamp is also an example of a non-ohmic component.

(b) (i) Sketch on the axes below the current-voltage characteristic for a filament lamp.



(2 marks)

(b) (ii) State, with reference to the current-voltage characteristic you have drawn, how the resistance of the lamp changes as the pd across its terminals changes.

.....

.....

(1 mark)

(c) A filament lamp has a power rating of 36 W when there is a pd across its terminals of 12 V.

(c) (i) Calculate the resistance of the filament when the pd across its terminals is 12 V.

answer = ... Ω

(2 marks)

(c) (ii) A student predicts that if the pd across the bulb is reduced to 6.0 V the power rating of the bulb would be 9.0 W. State and explain how in practice the power rating will be slightly different from this value.

.....

.....

.....

.....

.....

.....

(3 marks)

6)

A copper connecting wire is 0.75 m long and has a cross-sectional area of 1.3×10^{-7} m^2.

(a) Calculate the resistance of the wire.

resistivity of copper = 1.7×10^{-7} Ω m

resistance = ... Ω

(2 marks)

(b) A 12 V 25 W lamp is connected to a power supply of negligible internal resistance using two of the connecting wires. The lamp is operating at its rated power.

(b) (i) Calculate the current flowing in the lamp.

current = ... A

(1 mark)

(b) (ii) Calculate the pd across each of the wires.

pd = ... V

(1 mark)

(b) (iii) Calculate the emf (electromotive force) of the power supply.

emf = ... V

(2 marks)

(c) The lamp used in part (b) is connected by the same two wires to a power supply of the same emf but whose internal resistance is not negligible.

State and explain what happens to the brightness of the lamp when compared to its brightness in part (b).

.....

.....

.....

.....

.....

.....

(2 marks)

7)

(a) A student wishes to investigate how the resistance of a thermistor changes with temperature.

(a) (i) Draw a labelled diagram of a suitable circuit that would enable the student to measure the resistance of the thermistor.

(2 marks)

(a) (ii) Describe the procedure the student would follow in order to obtain accurate and reliable measurements of the resistance of the thermistor at different temperatures.

The quality of your written communication will be assessed in this question.

.....

.....

.....

.....

.....

.....

.....

.....

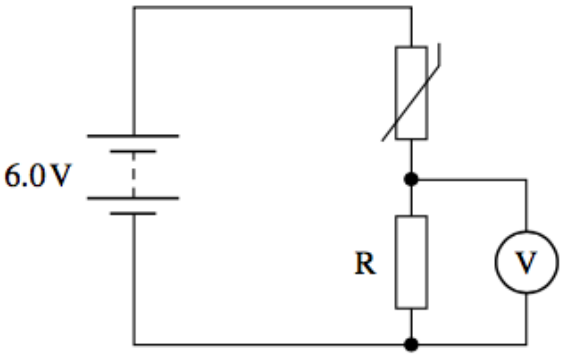
.....

.....

(6 marks)

(b) **Figure 1** shows a thermistor connected in series with a resistor, R, and battery of emf 6.0 V and negligible internal resistance.

Figure 1



When the temperature is 50 °C the resistance of the thermistor is 1.2 kΩ. The voltmeter connected across *R* reads 1.6 V.

(b) (i) Calculate the pd across the thermistor.

answer = ... V
(1 mark)

(b) (ii) Calculate the current in the circuit.

answer = ... A
(1 mark)

(b) (iii) Calculate the resistance of R quoting your answer to an appropriate number of significant figures.

answer = ... Ω

(2 marks)

(c) State and explain the effect on the voltmeter reading if the internal resistance of the battery in the circuit in part (b) was not negligible.

.....

.....

.....

.....

.....

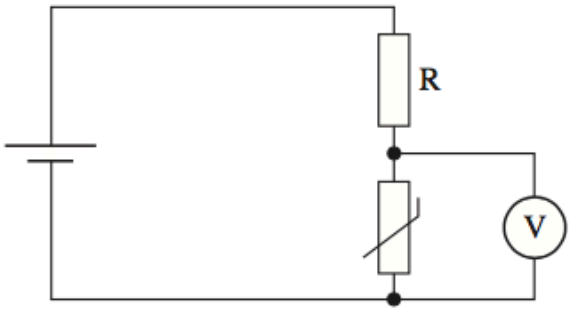
.....

(2 marks)

8)

A thermistor is to be used as a temperature sensor. In order to find out how the voltage across the thermistor varies with temperature the circuit shown in **Figure 3** is set up.

Figure 3



(a) Data have to be obtained so that a graph can be plotted to show how the reading on the voltmeter varies with temperature between 0 °C and 100 °C. Design an experiment, using this circuit, to obtain enough data to plot the graph. Your answer should include:

- details of the measurements taken
- details of how the temperature of the thermistor can be varied
- an explanation of the need for resistor R
- an explanation of how the thermistor can then be used to measure the temperature of a room.

The quality of your written communication will be assessed in your answer.

[6 marks]

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(b) The experiment you designed in part (a) is repeated with the voltmeter connected across R instead.
State and explain how the readings on the voltmeter would be different.

[3 marks]

.....

.....

.....

.....

.....

.....

9)

A student wishes to collect data so he can plot the *I-V* curve for a semiconductor diode.

(a) (i) Draw a suitable diagram of the circuit that would enable the student to collect this data.

(3 marks)

(a) (ii) Describe the procedure the student would follow in order to obtain an *I-V* curve for the semiconductor diode.

The quality of your written communication will be assessed in this question.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

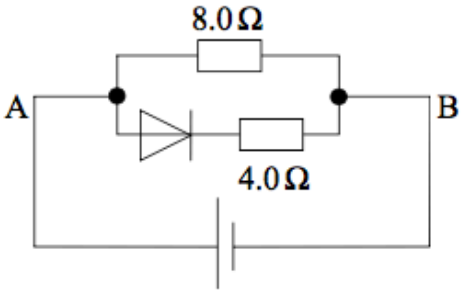
.....

.....

(6 marks)

(b) **Figure 1** shows an arrangement of a semiconducting diode and two resistors.

Figure 1



A 12.0 V battery is connected with its positive terminal to A and negative terminal to B.

(b) (i) Calculate the current in the 8.0 Ω resistor

.....

.....

.....

answer .....A

(2 marks)

(b) (ii) Calculate the current in the 4.0 Ω resistor if the p.d. across the diode, when in forward bias, is 0.65 V expressing your answer to an appropriate number of significant figures.

.....

.....

.....

.....

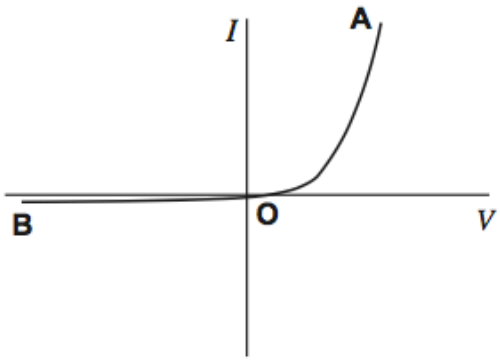
answer .....A

(3 marks)

10)

(a) The graph in **Figure 1** shows the current–voltage (I–V) characteristic curve for a semiconductor diode.

Figure 1



In order to produce this characteristic a student is given suitable equipment including an ammeter and a voltmeter.

(a) (i) Draw a labelled circuit diagram of the apparatus that the student could use to obtain the part of the characteristic from **O** to **A**.

[2 marks]

(a) (ii) Describe how the student could use the circuit in part (a)(i) to obtain sufficient measurements to draw the part of the characteristic from **O** to **A**. Your account should include:

- details of how different readings of I and V are obtained
- a consideration of safety precautions when using the diode
- a discussion of the range and number of measurements that need to be taken
- a discussion of the advantages of using a data logger to obtain the measurements.

The quality of your written communication will be assessed in your answer.

[6 marks]

(a) (iii) Suggest how the circuit you drew in part (a)(i) could be modified to obtain the characteristic from **O** to **B**.

[1 mark]

(b) The student wants to find out how the resistance of the diode changes between **O** and **A**.

(b) (i) Describe how the student could use the characteristic to determine how the resistance varies as the potential difference (pd) between **O** and **A** increases.

[2 marks]

(b) (ii) State how you would expect the resistance of the diode to vary as the pd increases.

[1 mark]